AN ASSESSMENT OF THE BOTTOM FAUNA AND SEDIMENTS OF THE DETROIT RIVER

February 1984

Ontario
Ministry of the Environment

The Honourable
Andrew S. Brandt
Minister

Dr. Allan E. Dyer
Deputy Minister

AN ASSESSMENT OF THE BOTTOM FAUNA AND SEDIMENTS OF THE DETROIT RIVER

February 1984

by

S. Thornley
Technical Support Section
Southwestern Region

and

Y. Hamdy
Great Lakes Section
Water Resources Branch

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Mr. David S. Osmond[e] was responsible for the 1968 survey.

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[a]Dr. Green is associate professor at the University of Western Ontario in London, Ontario.

[b]Dr. McGillivray is a statistical limnologist with the Great Lakes Section of the Ministry of the Environment.

[c]Mr. Hiltunen is with the Great Lakes Fishery Laboratory, U.S. Fish and Wildlife Service, Ann Arbor, Michigan 48105.

[d]Ms. Simpson is with the Great Lakes Section, Water Resources Branch of the Ministry of the Environment.

[e]Mr. Osmond is currently with Gartner Lee Associates Limited, Markham, Ontario.

SUMMARY OF FINDINGS

A comparison of biological surveys of the Detroit River in 1968 and 1980 showed differences in the types and distribution of benthic organisms recovered. The major difference was a dissimilarity in the macrozoobenthos comparing the American and Canadian shorelines.

A balanced community structure indicative of satisfactory water quality conditions existed along the entire Canadian shoreline both in 1968 and 1980. Canadian sources impacting on the biology did not seriously disrupt the macrozoobenthos.

In contrast, along the American shoreline, a seriously disrupted benthos was evident. The disruption began at the mouth of the Rouge River and was clearly evident both in 1968 and 1980. The macrozoobenthos near the mouth of the Rouge River was greatly reduced in numbers and types of organisms. Downstream from the Rouge River pollution-tolerant aquatic worms numbered over 1 million per m^2 of river bottom during both surveys, demonstrating persistent and severe organic enrichment. High numbers of worms, representing a lesser degree of enrichment, persisted along the shore to the mouth of the river.

Differences over time were detected in the macrozoobenthos of the Detroit River comparing 1968 and 1980 data. There was an increase in the types of organisms recovered in 1980, particularly along the Canadian shoreline. Also, certain organisms indicative of satisfactory water quality such as the mayfly, Hexagenia limbata, were better represented in the river in 1980. The mayfly was found at 70% of stations in 1980 compared to only 26% in 1968. The recovery of the mayfly was particularly noticeable in the centre and along the Canadian shoreline of the river and is indicative of improved conditions. The occurrence of mayfly along the American shoreline, although somewhat improved in 1980, was still meager compared to stations in the middle of the river and along the Canadian shoreline. Satisfactory water quality conditions are still not evident along most of the American shoreline.

The river sediments are mainly characterized by coarse materials due to moderate to high current velocities which carry the fine particles to the depositional zones in Lake Erie. Contaminants found in the sediments are mainly attributable to discharges from the U.S. shoreline of the river. Metal concentrations were, in general, highly intercorrelated along the U.S. shore, indicating that continuous, rather than discrete sources, were responsible. Along the Canadian shore, metal levels were attributed to localized sources since intercorrelation between metal concentrations was generally poor.

The contamination of sediments along the Ontario shoreline of the river was localized near known sources such as the Little River, West Windsor sewage treatment plant; Turkey Creek and Riviere aux Canard. Almost the entire U.S. shoreline sediments exhibited elevated levels (above provincial dredging guidelines) of contaminants such as heavy metals and PCBs. Levels of one order of magnitude higher than those on the Canadian shore were prevalent along the U.S. shore. Sediments around Fighting Island indicated levels well below the Ministry of the Environment (MOE) dredging guidelines.

The decline of mercury levels in the river observed during the period 1970-1980 is attributed to the controls that were instituted on mercury losses (e.g. U.S. Wyandotte). Significant increases in cadmium, chromium, copper, lead, nickel and zinc in the vicinity of the mouth of the Rouge River along the U.S. shoreline during the same period suggest recent inputs from industrial and municipal sources.

INTRODUCTION

The Detroit River, the connecting waterway between Lake St. Clair and Lake Erie, flows in a southerly direction about 50 kilometres from Peach Island at Lake St. Clair to its mouth at Lake Erie (Figure 1A).

The upper thirteen miles of the river, having an average width of 800 m and a mean depth of 8 m, are divided by Peach Island and Belle Isle at the upper end where the water enters from Lake St. Clair (Figure 1B). The lower section of the river contains Fighting Island (Canadian waters), Grosse Ile (U.S. waters) and several small islands with large areas of marshland. In the lower river, shipping channels have been cut through exposed underlying rock to a depth of 9 m. Residential and commercial development and recreational facilities are found along both sides of the river from Lake St. Clair to about the mouth of the Rouge River. Heavy industry is located on the U.S. side from Zug Island, downstream through the Trenton Channel, as far south as the river mouth (Figure 1B).

Extensive use has been made of the many islands for industrial and recreational purposes. Fighting Island was used for the disposal of waste materials resulting from the manufacture of caustic soda and soda ash. A rehabilitation pilot project is currently underway at Fighting Island to ascertain whether it is feasible to support vegetation using sewage sludge from the Detroit Municipal Wastewater Treatment Plant. Grassy Island and Mud Island are being used for the disposal of material from dredging operations; and Belle Isle and Bois Blanc Island are devoted for recreational purposes (Figure 1B).

In 1968 and 1970, Ministry studies in the river that related to the identification of benthos and contaminants in sediments revealed extensive degradation in the river sediment quality (Ontario Ministry of the Environment, unpublished data).

This study is an update of the previous investigations and will provide baseline conditions for future studies to be undertaken during the intensive year (1986) for interconnecting channels

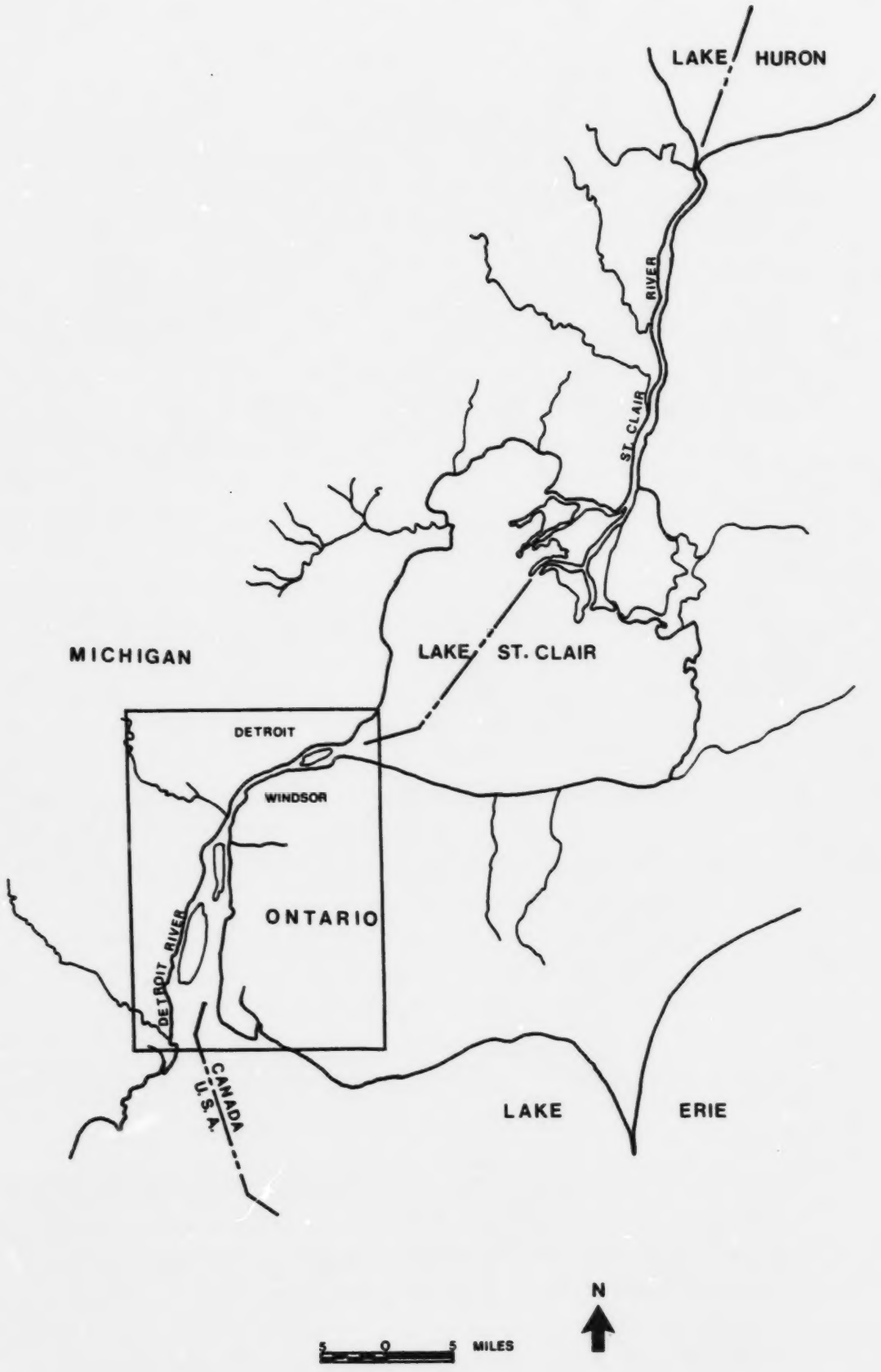

FIGURE 1A DETROIT RIVER - STUDY AREA

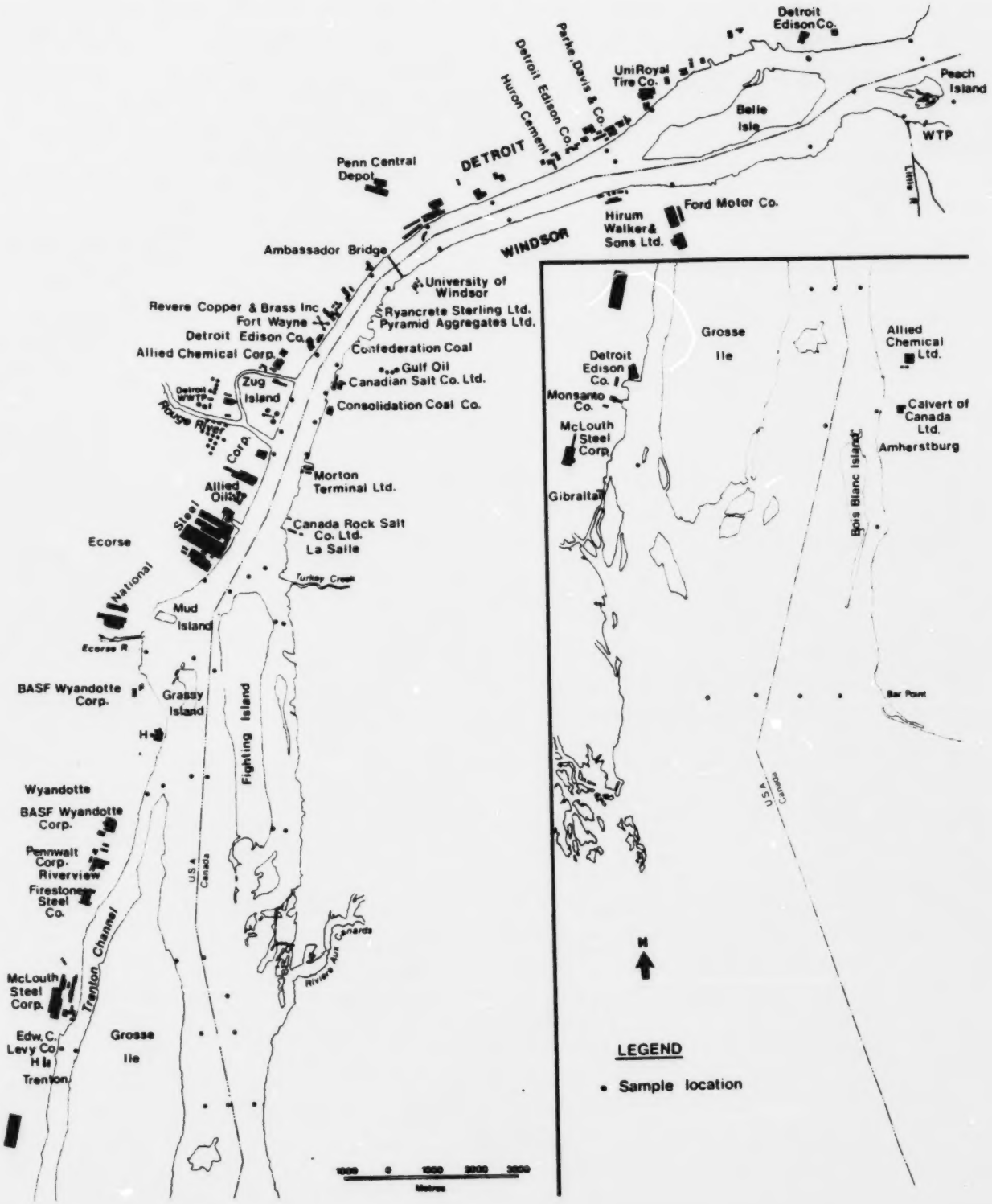

FIGURE 1B DETROIT RIVER - STUDY AREA.

under GLISP (Great Lakes International Surveillance Plan). The study can also ascertain whether efforts expended in pollution abatement measures that took place during the last decade have resulted in improvements in the river sediment quality. No attempt was made to sample contaminants in point or non-point sources discharging to the river.

METHODS

Biological surveys of the Detroit River were conducted from May 13 to July 4 in 1968 and from May 27 to June 4 in 1980. A Ponar grab sampler (21.5 cm x 24 cm) was used to collect benthic organisms from 53 and 59 stations in 1968 (5 grabs per station) and 1980 (3 grabs per station) respectively (Figure 2). At any station, grab samples were always collected at the same distance downstream. Distance from shore varied, however, and therefore, grabs cannot be considered as true replicate samples. All grabs were collected in a narrow band between the shoreline and the shipping channel. No samples were collected from shipping channels. Between the two surveys, a total of 70 stations have been sampled, with 43 stations common to both surveys.

In conjunction with macrozoobenthos sampling, shipek grab samples of surficial sediments (0-3 cm) were taken at the 59 sampling stations for chemical analysis during the survey period. Sediment samples were submitted to the Ministry of the Environment (MOE) main laboratory in Toronto for total metal analysis (mercury, cadmium, zinc, chromium, lead, nickel and iron), which included acid digestion and atomic absorption spectrophotometry according to methods described by Darcel (1). Samples were partitioned for analysis of percent loss on ignition, nutrients and Wentworth particle size. Duplicate samples were transported in solvent rinse containers for analysis of chlorinated hydrocarbons and pesticides including DDT and metabolites, lindane, polychlorinated biphenyls (PCBs), hexachlorobenzene (HCB), dieldrin, endrin, thiodan and chlordane. Organic contaminant analyses were performed according to standard MOE analytical and quality control procedure (2).

The separation of benthic organisms from the sediments was performed on board the survey vessel by sieving samples through a screen pail (U.S. Sieve Series - Standard No. 30 sieve). Later the same day organimsms were sorted, enumerated and preserved in alcohol or formalin for final identificaton to the lowest taxonomic rank possible. In samples with a large number of worms (and less frequently midges), one hundred specimens were identified and extrapolations were based on these sub-samples.

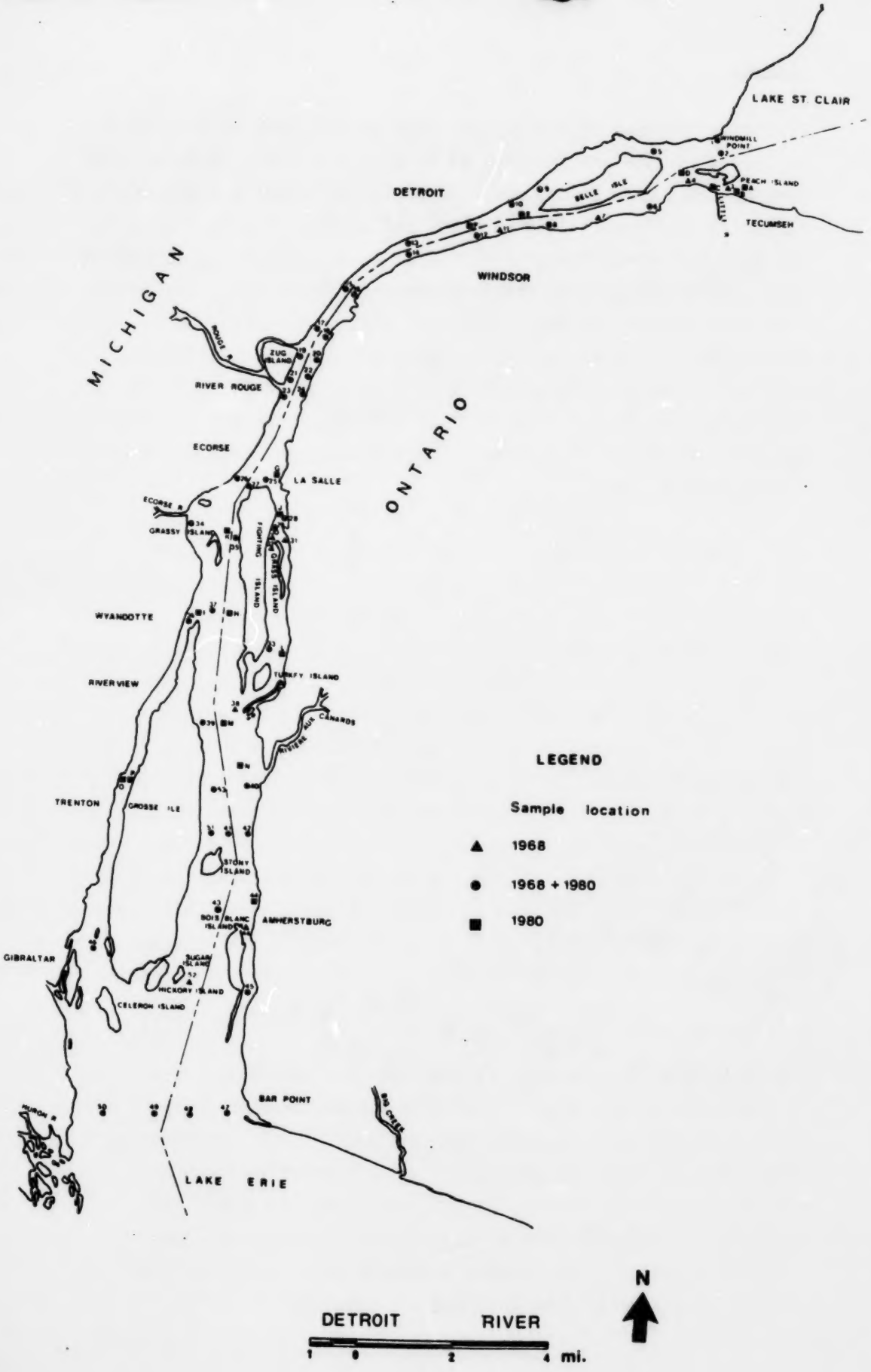

FIGURE 2 DETROIT RIVER STATION LOCATIONS FOR 1968 AND 1980

Following identification, taxa lists were examined for temporal differences in data between 1968 and 1980 and for spatial differences in community structures along the river in both years. Differences were derived through an interpretation of the ecology of the river (using indicator organisms, analysing functional groups, etc.) and from the results of univariate and multivariate statistical analyses (for data reduction and clustering).

RESULTS AND DISCUSSION

BOTTOM FAUNA - 1968 and 1980

Macroinvertebrate identifications for 1968 and 1980 are found in Tables 1 and 2 respectively. Figures 3, 4 and 5 display the average number of taxa per station and the average number of organisms per m^2 in four major sections of the Detroit River that were arbitrarily delineated to illustrate differences along the river. (Taxa lists for 1968 and 1980 will be made available upon request.)

Results from individual grab samples were averaged to produce the station averages for numbers and taxa. Variability among grabs at a station was often considerable and many grabs would undoubtedly have to be collected to best understand the variability. The collection of three samples has nonetheless proven satisfactory and seems to adequately represent conditions in the river.

During both surveys, results from stations in the upper section defined background conditions. That is, conditions before the introductions from major pollution sources along the shorelines. The benthic communities in the first (upper) section were, during both surveys, reasonably well-balanced with the presence of organisms sensitive to pollution (mayflies, caddisflies), organisms more tolerant of pollution (many of the worms and midges) and the presence of those organisms intermediate (facultative) in their sensitivity to pollution. For the purposes of Figures 3, 4, and 5, all worms and midges were considered pollution tolerant. All mayflies and caddisflies were considered sensitive (intolerant) to pollution. All other organisms were treated as facultative organisms.

The balanced community structure found in the upper section persisted along the entire eastern or Canadian shoreline of the river during both surveys. Comparing the 43 stations sampled during both surveys, there was an increase in the number of taxa per station from 1968 to 1980 ($P<.01$) for the 20 stations found in Canadian waters. There appeared to be an increase in the number of organisms from 1968 to 1980 (Figure 5), however, this was not statistically significant. There were fewer worms in 1980 ($P<.05$) suggesting an improving community structure.

Table 1. Macroinvertebrates Collected in the Detroit River during 1968.

Ephemeroptera (mayflies)
- Ephemeridae
  - Hexagenia limbata
  - Hexagenia rigida*
  - Ephemera simulans*
- Heptageniidae
  - Stenonema
- Baetiscidae
  - Baetisca
- Caenidae
  - Caenis
- Baetidae
  - Baetis
- Ephemerellidae
  - Ephemerella

Trichoptera (caddisflies)
- Hydropsychidae
  - Hydropsyche
  - Cheumatopsyche
  - Macronema*

Odonata
- Coenagrionidae (damselflies)
- Gomphidae (dragonflies)

Amphipoda (scuds)
- Gammaridae
  - Gammarus
- Taltridae
  - Hyallela azteca

Isopoda (sow bug)
- Asellidae
  - Asellus

Decapoda (crayfish)
- Astacidae
  - Orconectes obscurus*

Acarina (water mites)

Gastropoda (snails)
- Planorbidae
  - Gyraulus
- Viviparidae
  - Campeloma
- Amnicolidae
  - Bithinia tentaculata
  - Amnicola
  - Somatogyrus
- Ancylidae
  - Ferrissia
- Pleuroceridae
  - Goniobasis
- Physidae
  - Physa
- Valvatidae
  - Valvata sincera
  - Valvata tricarinata*
- Lymnaeidae
  - Lymnaea*

Pelecypoda (clams)
- Sphaeriidae
  - Sphaerium
  - Pisidium
- Zampsilinae
  - Ligumia*

Hirudinea (leeches)

Nematoda (round worms)

Turbellaria (flat worms)

Coelenterata
- Hydrozoa (hydra)

Hemiptera
- Corixidae (water boatman)

Diptera (fly larva)
- Ceratopogonidae (biting midge)
  - Palpomyia*

Table 1 (cont'd)

Chironomidae (midge)
  Tanypodinae
    Tribe Macropelopiini
      Procladius
      Anatopynia*
Unidentified midge

  Chironominae
    Tribe Chironomini
      Chironomus
      Cryptochironomus
      Dicrotendipes*
      Polypedilum
      Stenochironomus*
      Xenochironomus

    Tribe Tanytarsini
      Tanytarsus*

Oligochaeta (worms)
  Tubificidae
    Aulodrilus americanus
    Aulodrilus pluriseta
    Ilyodrilus templetoni*
    Limnodrilus cervix
    L. claparedeianus
    L. hoffmeisteri
    L. profundicola**
    L. udekemianus
    Peloscolex ferox
    P. freyi*
    P. multisetosus
    Potamothrix vejdovskyi
    P. moldaviensis
    Tubifex ignotus*
    T. tubifex
    T. templetoni*
  Lumbriculidae
    Stylodrilus
    Rhyzodrilus

  Enchytraeidae

  Naididae
    Chaetogaster*
    Nais pardalis
    Ophidonais sepentina
    Stylaria lacustria*

* Organisms present only in 1968.
** The presence of Limnodrilus profundicola in the Detroit River, in the abundance indicated is questionable. Mis-identification is possible. However, a non-permanent preparation was used in the identification procedure and no voucher specimens were retained.

Table 2. Macroinvertebrates Collected in the Detroit River during 1980.

Ephemeroptera (mayflies)
- Ephemeridae
  - Hexagenia limbata
- Heptageniidae
  - Stenonema
- Tricorythidae
  - Tricorythodes*
- Baetiscidae
  - Baetisca
- Caenidae
  - Caenis

Trichoptera (caddisflies)
- Hydropsychidae
  - Hydropsyche
  - Cheumatopsyche
- Leptoceridae
  - Ceraclea
  - Oecetis
  - Triaenodes*
- Polycentropodidae
  - Neureclipsis*
  - Polycentropus*
  - Phylocentropus*

Coleoptera (beetles)

Odonata
- Coenagrionidae (damselflies)
- Gomphidae (dragonflies)

Hempitera (bugs)
- Corixidae

Amphipoda (scuds)
- Gammaridae
  - Gammarus
- Haustoriidae
  - Pontoporeia affinis*
- Taltridae
  - Hyallela azteca

Isopoda
- Asellidae
  - Asellus

Decapoda (crayfish)
- Astacidae
  - Cambarinae*
  - Orconectes propinquus*

Acarina (water mites)

Gastropoda (snails)
- Planorbidae
  - Gyraulus
- Viviparidae
  - Campeloma
- Amnicolidae
  - Bithinia tentaculata
  - Ammicola
  - Somatogyrus
- Ancylidae
  - Ferrissia
- Pleuroceridae
  - Goniobasis
  - Pleurocera*
- Physidae
  - Physa
- Valvatidae
  - Valvata sincera

Pelecypoda (clams)
- Sphaeriidae
  - Sphaerium
  - Pisidium
- Unionidae*

Hirudinea (leeches)

Nematoda (round worms)

Turbellaria (flat worms)

Coelenterata
- Hydrozoa (hydra)

Chironomidae (midge)
- Tanypodinae
  - Tribe Pentaneurini
    - Ablabesmyia*
  - Tribe Macropelopiini
    - Procladius
  - Tribe Coelotanypodini
    - Coelotanypus*
- Chironominea
  - Tribe Chironomini
    - Chironomus
    - Cryptochironomus

Table 2 (cont'd)

- Parachironomus*
- Parachladopelma*
- Endochironomus*
- Tribelos*
- Zenchironomus*
- Goeldichironomus*
- Glyptotendipes*
- Pseudochironomus*
- Polypedilum
- Paralauterborniella*
- Paratendipes*
- Strictochironomus*

Tribe Tanytarsini
- Rheotanytarsus*
- Micropsectra*

Diamesinae

Tribe Diamesini
- Diamesa*
- Potthastia*

Tribe Prodiamesini
- Monodiamesa*

Orthocladiinae
- Cricotopus*
- Metriocnemus*
- Orthocladius*
- Psectrocladius*

Oligochaeta (worms)

Tubificidae
- Aulodrilus americanus
- Aulodrilus pluriseta
- Branchiura sowerbyi
- Limnodrilus cervix
- L. claparedeianus
- L. hoffmeisteri
- L. maumeensis
- L. profundicola**
- L. udekemianus
- Peloscolex ferox
- P. multisetosus
- Potamothrix moldaviensis
- P. vejdovskyi
- Tubifex tubifex
- T. templetoni*

Lumbriculidae
- Stylodrilus heringianus

Enchytraeidae

Naididae
- Nais pardalis
- Ophidonais sepentina

* Organisms present only in 1980.

** The presence of Limnodrilus profundicola in the Detroit River, in the abundance indicated is questionable. Mis-identification is possible. However, a non-permanent preparation was used in the identification procedure and no voucher specimens were retained.

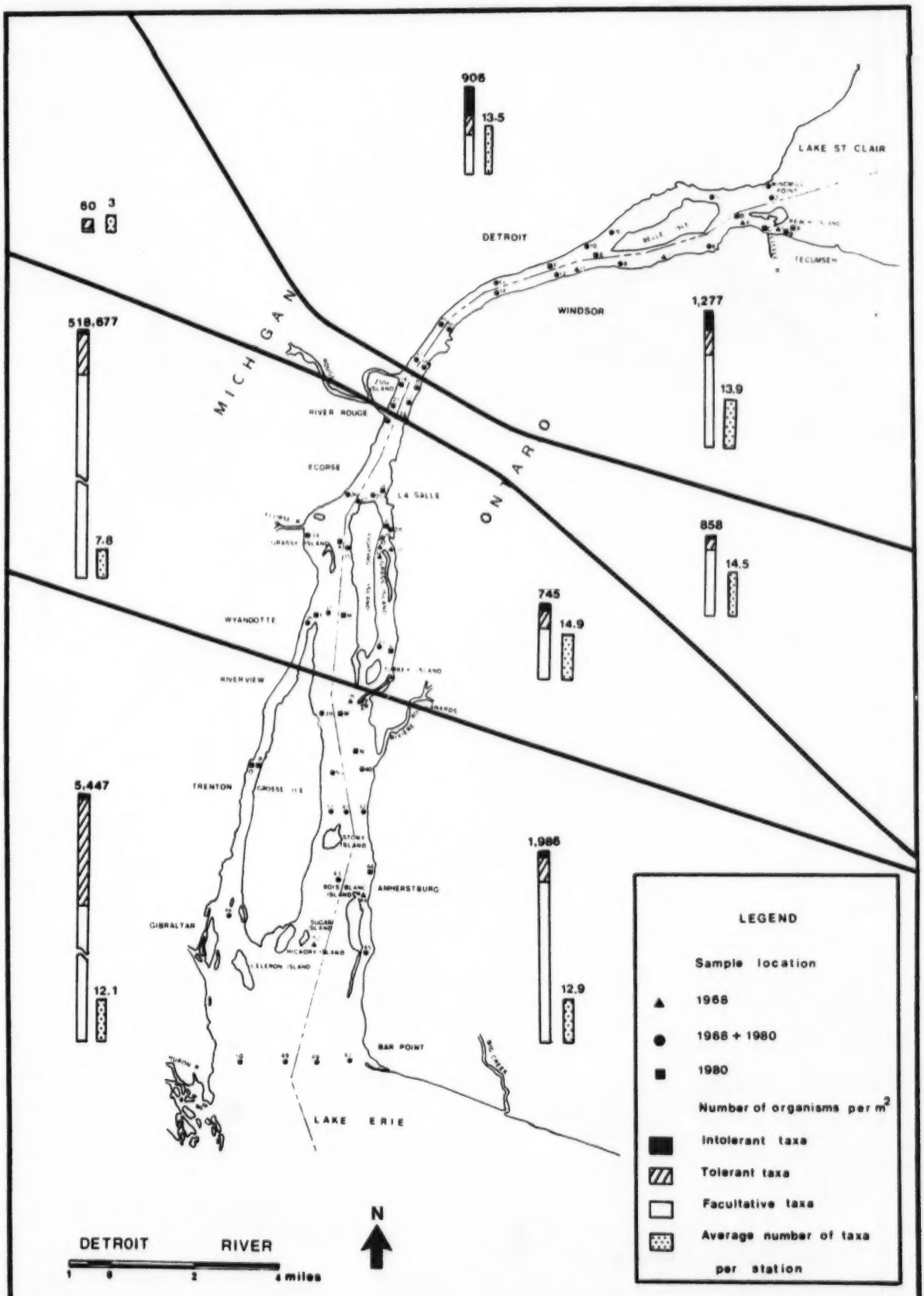

FIGURE 3 AVERAGE NUMBER OF TAXA PER STATION AND AVERAGE NUMBER OF ORGANISMS PER M^2 IN FOUR MAJOR SECTIONS OF THE DETROIT RIVER, 1968.

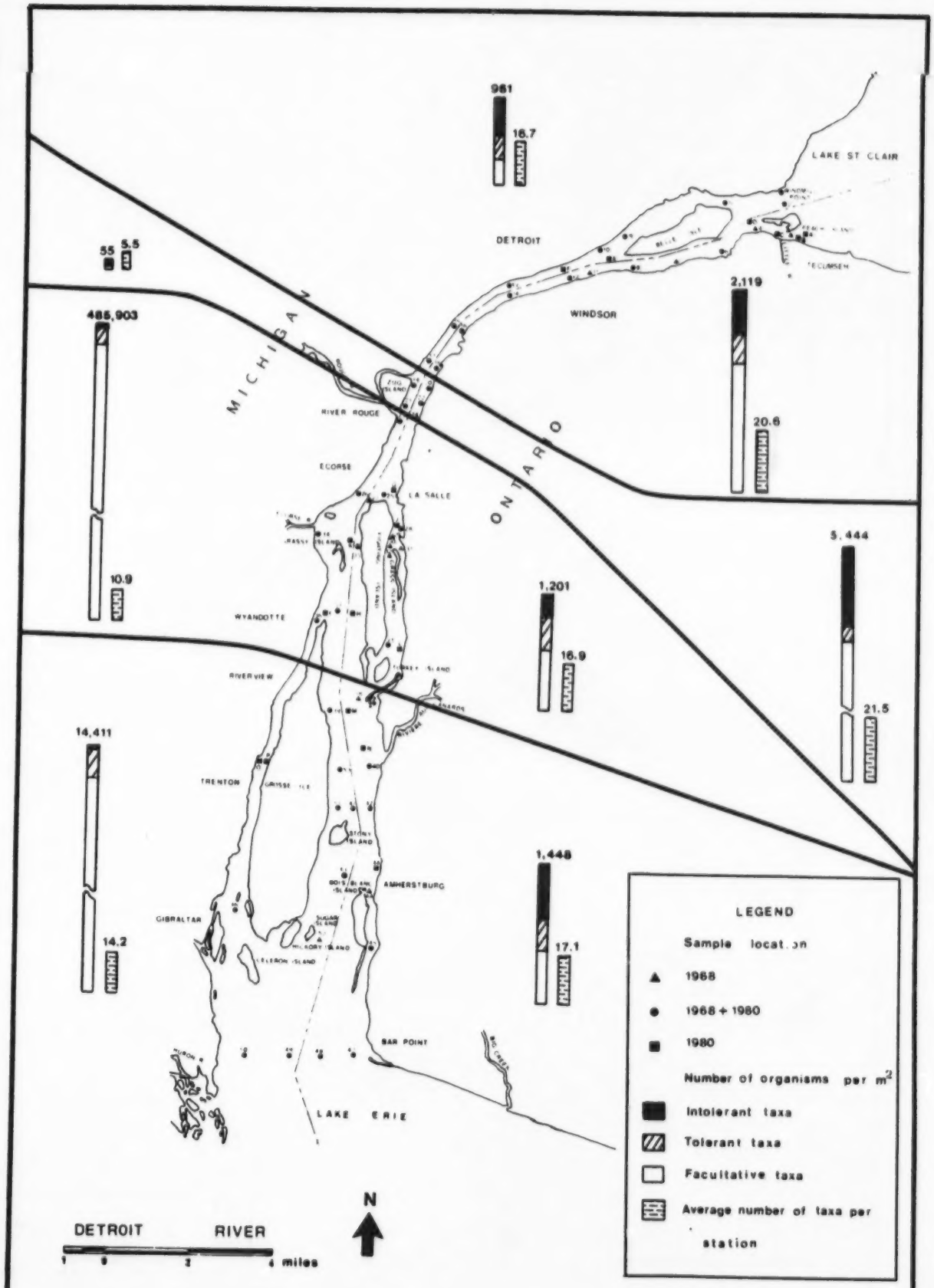

FIGURE 4 AVERAGE NUMBER OF TAXA PER STATION AND AVERAGE NUMBER OF ORGANISMS PER M^2 IN FOUR MAJOR SECTIONS OF THE DETROIT RIVER, 1980.

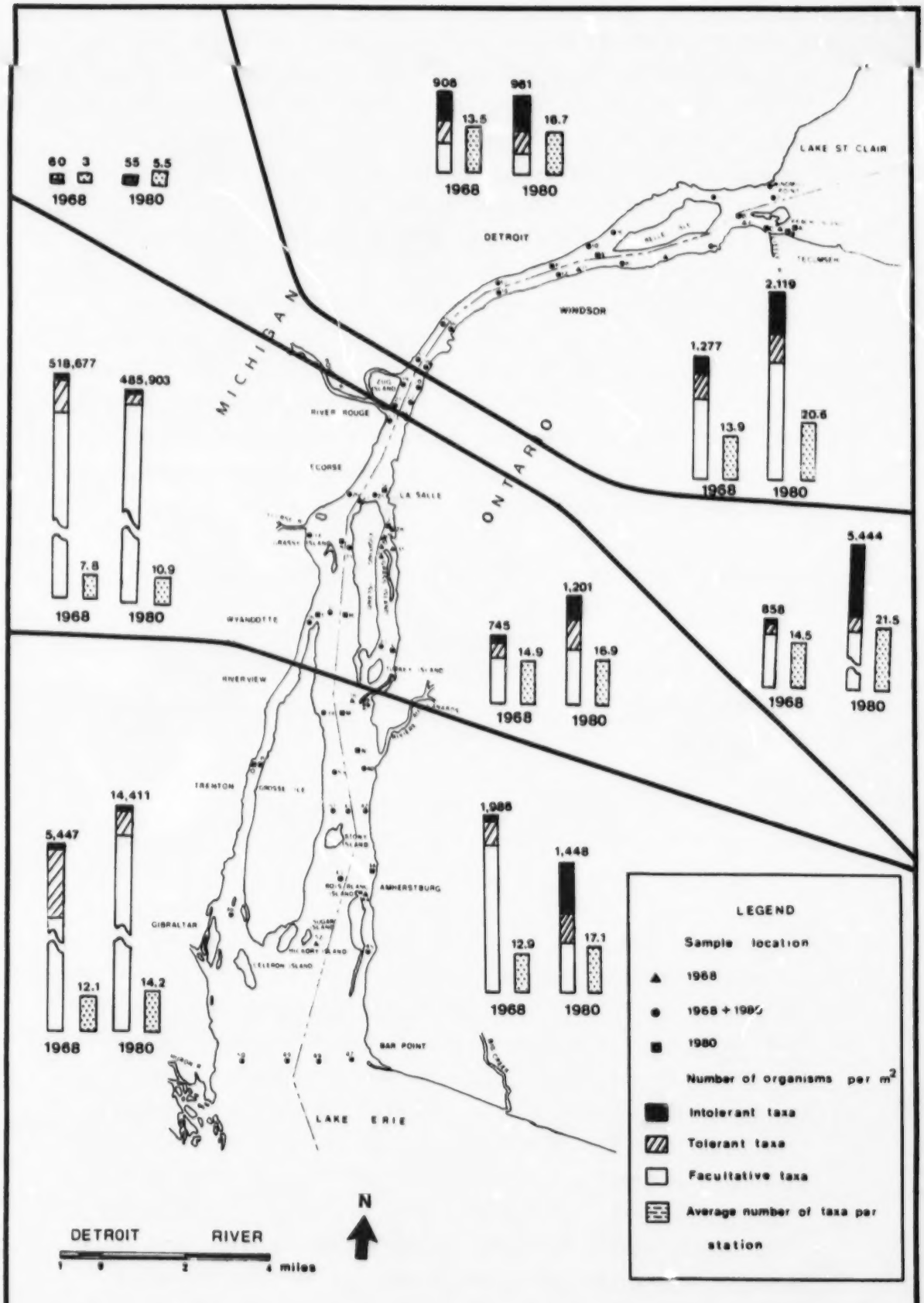

FIGURE 5 A COMPARISON OF THE AVERAGE NUMBER OF TAXA PER STATION AND THE AVERAGE NUMBER OF ORGANISMS PER M^2 IN FOUR MAJOR SECTIONS OF THE DETROIT RIVER, 1968 AND 1980.

In contrast, downstream from the head of the river along the western or U.S. shoreline, the community balance became noticeably disrupted both in 1968 and 1980. The disruption began in the narrow second section, isolating stations near Zug Island at the mouth of the Rouge River. Both the average number of organisms per m^2 and the average number of taxa per station were greatly reduced. In 1968 organisms sensitive to pollution were absent from this zone.

In the next section of river along the U.S. shoreline, a community imbalance was reflected by exceedingly high numbers of organisms per m^2. These high numbers were greatly influenced by the number of worms. For example, in this section the worms accounted for 78 percent of the total organisms collected both in 1968 and 1980. Numbers were commonly in excess of 90 percent of total numbers recovered. The overall averages were lowered by the inclusion of station 37, which seemed to be out of the influence of shoreline discharges. Station 37 had 16 percent and zero percent worms in 1968 and 1980, respectively.

In the final section along the U.S. shoreline, a disrupted macro-benthos was still evident, again the result of high numbers of aquatic worms.

Unlike the Canadian shoreline, there were no changes in taxa, numbers of organisms or percent worms along the U.S. shoreline from 1968 to 1980.

Accompanying changes in numbers of groups of organisms were changes in the distribution of organisms. One of the more significant changes was the resurgence of the mayfly, Hexagenia limbata. In 1968, Hexagenia limbata nymphs were recovered from only 14 stations (26 percent of stations) 11 of which were in Canadian waters. The maximum density of nymphs recovered was 2 per grab and none was found downstream from Stoney Island, approximately the lower 10 kilometres of the river. In 1980, Hexagenia nymphs were found at 41 stations (70 percent of stations) and distribution had improved along both sides of the river. Hexagenia nymphs were found at 17 stations in American waters and 24 stations in Canadian waters. In 1980, Hexagenia limbata was present in the lower 10 kilometres of

the river including representation in both American and Canadian waters. Abundance was also much greater in 1980, averaging 9 nymphs per grab and attaining a maximum of 95 Hexagenia nymphs in a single grab at Station 20. Station 20, located in Canadian waters opposite the mouth of the Rouge River, had an average of 57 nymphs per grab which is the equivalent average of 1156 per m^2. Figures 6 and 7 display the abundance and distribution of the mayfly nymph Hexagenia limbata for 1968 and 1980, respectively.

Unionid clams, not found at all in the Detroit River in the 1968 survey were found in 1980. The distribution was interesting in that their presence appeared to be restricted to cleaner, swifter areas of the river. The clams were only found at 13 stations. Ten of these stations were in the upper portion of the first section as defined in Figures 3, 4 and 5 (10 of the first 15 stations starting at the head of the river). The next two stations where unionid clams were found were on the shoals at the head of Fighting Island. The last station where a unionid clam was found was in a good flow area between Grosse Ile and the Canadian shore.

Despite obvious improvements in the water quality of certain areas of the Detroit River as indicated by the re-establishment of the mayfly, Hexagenia limbata, there were still problem areas. They were reflected by other invertebrates such as the aquatic worms. As a group, these organisms can be indicative of a problem when their numbers are disproportionately large. In American waters downstream from the mouth of the Rouge River their numbers commonly constituted 80 to 99 percent of the total number of invertebrates recovered. At stations 26 and 34, their numbers reached 1.5 and 1.9 million per m^2 in 1980. In particular, various species of Limnodrilus along with Tubifex tubifex dominated at these locations. The 1980 data were essentially unchanged from 1968 and represented a continuing major disruption of the benthos.

An effort was made to define natural groups of stations by a cluster analysis of taxa abundance at each station. To maintain comparability between 1968 and 1980 only the 43 stations sampled in both years were used. The groups generated by a cluster analysis depend greatly on the type of input data used. Various authors have

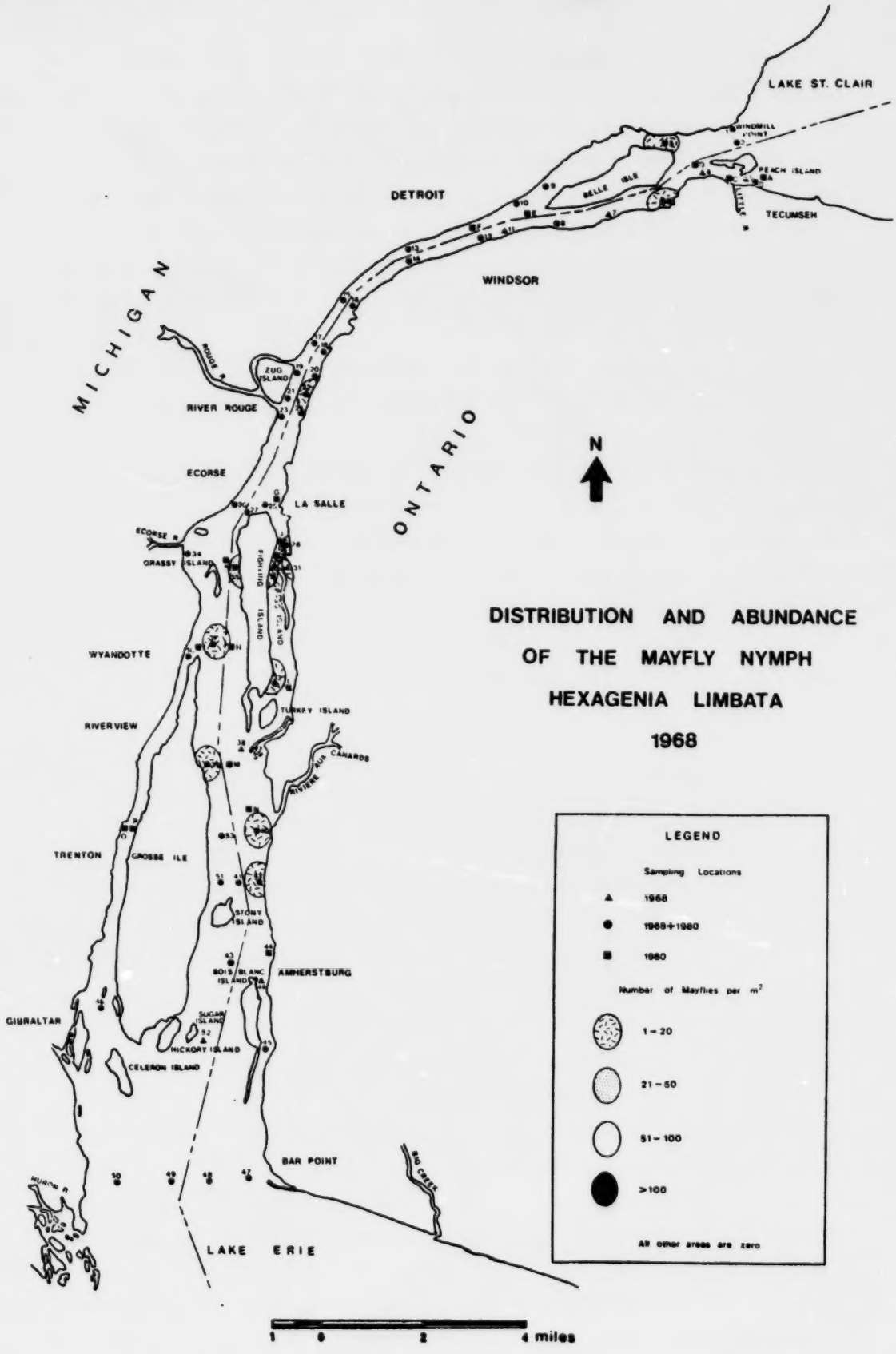

FIGURE 6 DISTRIBUTION AND ABUNDANCE OF THE MAYFLY NYMPH HEXAGENIA LIMBATA IN THE DETROIT RIVER, 1968.

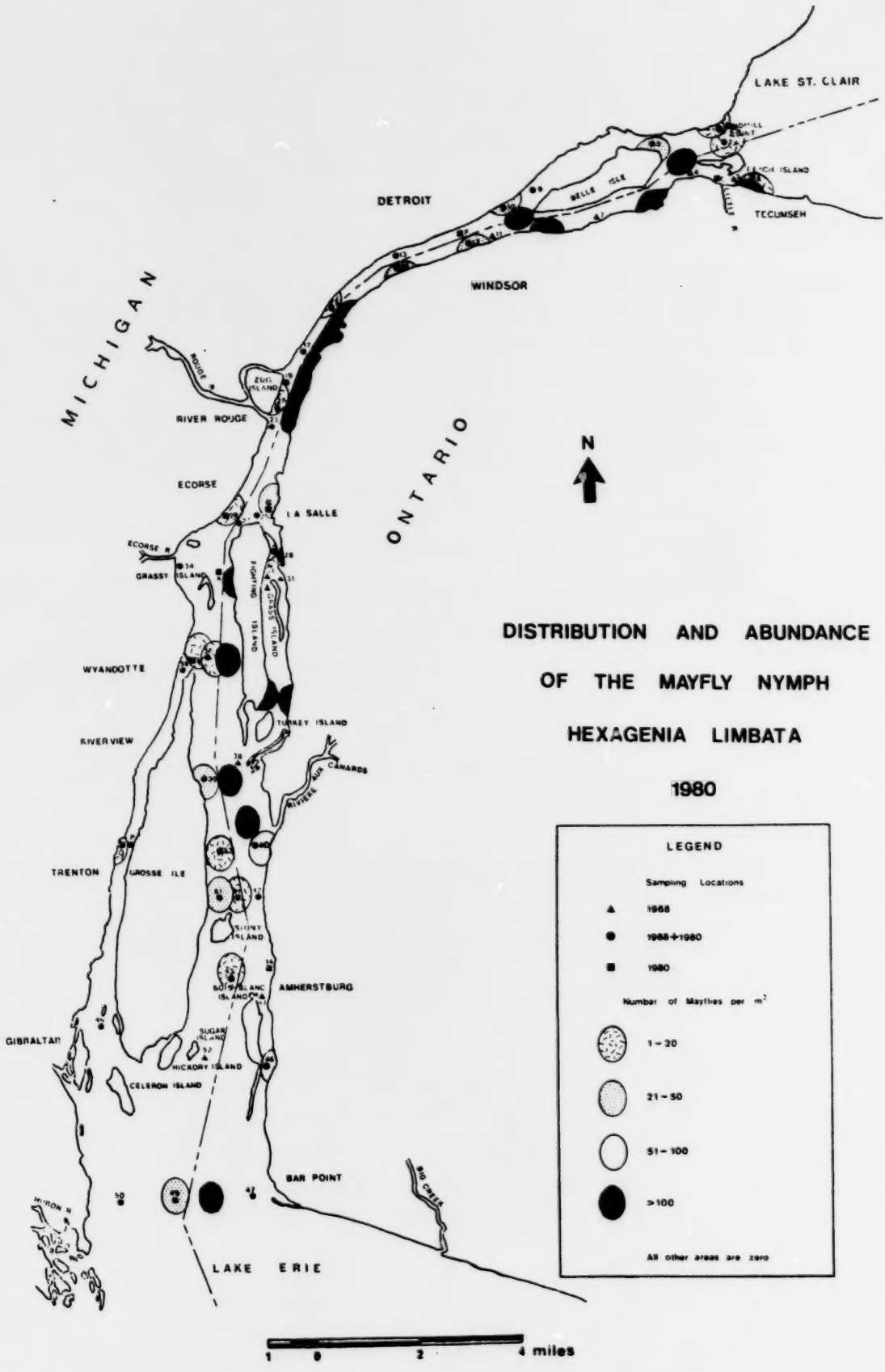

FIGURE 7 DISTRIBUTION AND ABUNDANCE OF THE MAYFLY NYMPH HEXAGENIA LIMBATA IN THE DETROIT RIVER, 1980.

chosen to input diversity indices, abundances of all taxa, or abundance of taxa comprising a subset of the entire taxa list. The 50 most important of the 96 taxa identified were input into the cluster analysis to avoid unduly weighting rare taxa. Importance was defined by Orloci's ranking criterion (3) in which taxa are ranked according to the amount of variation each contributes to the total variations of the data set. The best 50 taxa accounted for 90% of the total variation of the data set. Following selection of the 50 input taxa, all abundance data for these taxa were log transformed (log (x+1), since log (0) is undefined) to improve distributional and variance properties and to express variation on a common scale. Log transformation is usual for abundance or density data.

A hierarchical agglomerative cluster analysis (4, 5) produced several revealing two and three cluster solutions (Figure 8). In any given year there were essentially only two clusters - a and b for 1968 and a and c for 1980 (Figures 9 and 10).

In 1968 differences between the clusters are evident through examination of the aquatic worms. Differences in both the number of worms (log (x+1)) and the percentage of worms were highly significant ($P < .001$). The dominance of worms affected differences in total taxa between the two clusters ($P < 0.1$). Cluster b had the larger numbers and percentage of worms and fewer taxa and was therefore judged to represent poorer conditions compared to stations in cluster a.

The influence of aquatic worms on the clustering was also found in 1980. The differences in the total worms (log (x+1)) and percentage of worms were again highly significant ($P < .001$). Cluster c had the higher number and percentage of worms. In 1980 there was not a difference in the number of total taxa between the clusters.

FIGURE 8 DENDOGRAM OF HIERARCHIAL AGGLOMERATIVE CLUSTER ANALYSIS ON 1968 AND 1980 BENTHIC DATA FOR THE DETROIT RIVER.

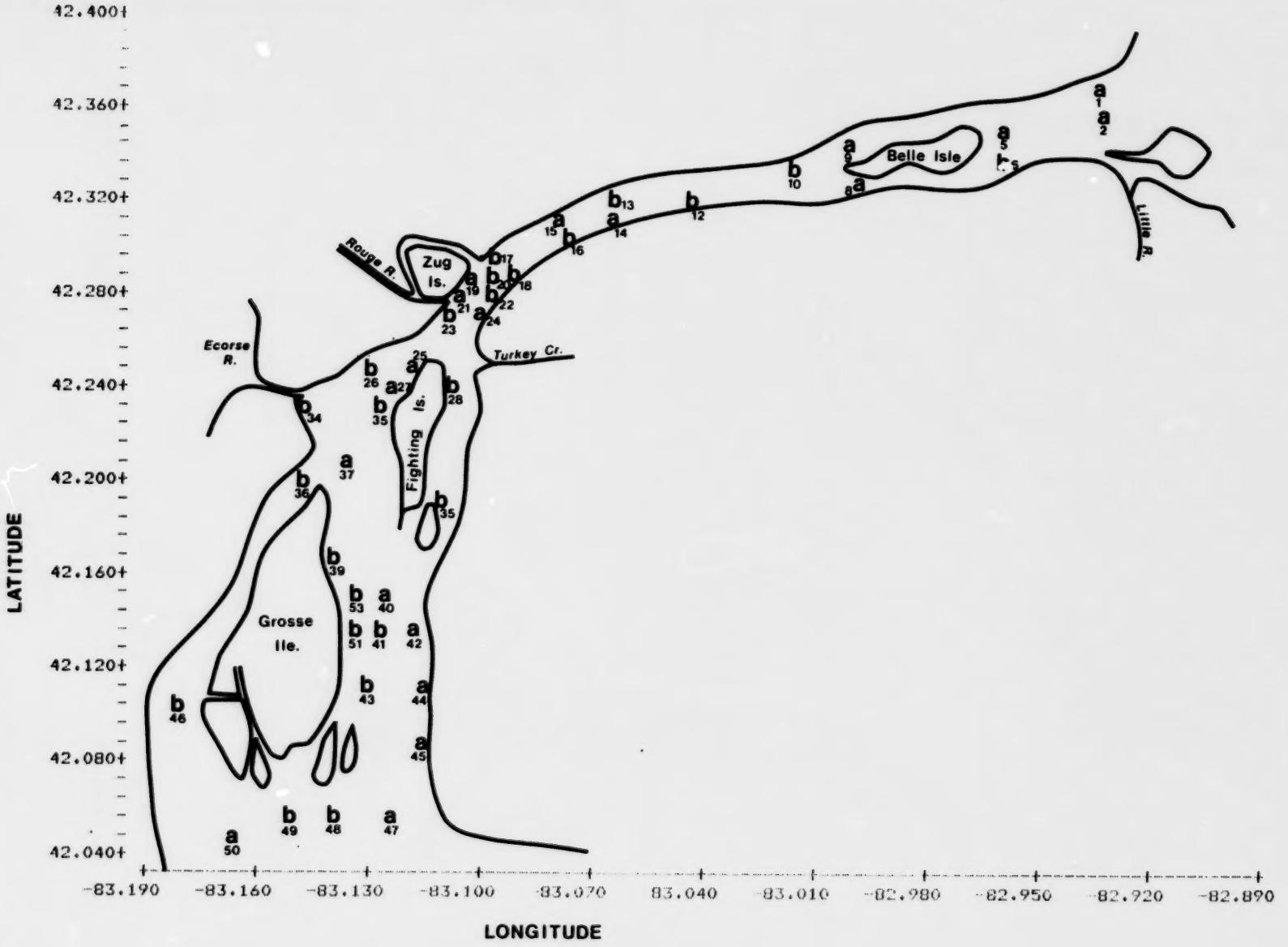

FIGURE 9 DETROIT RIVER THREE-CLUSTER SOLUTION FOR 1963

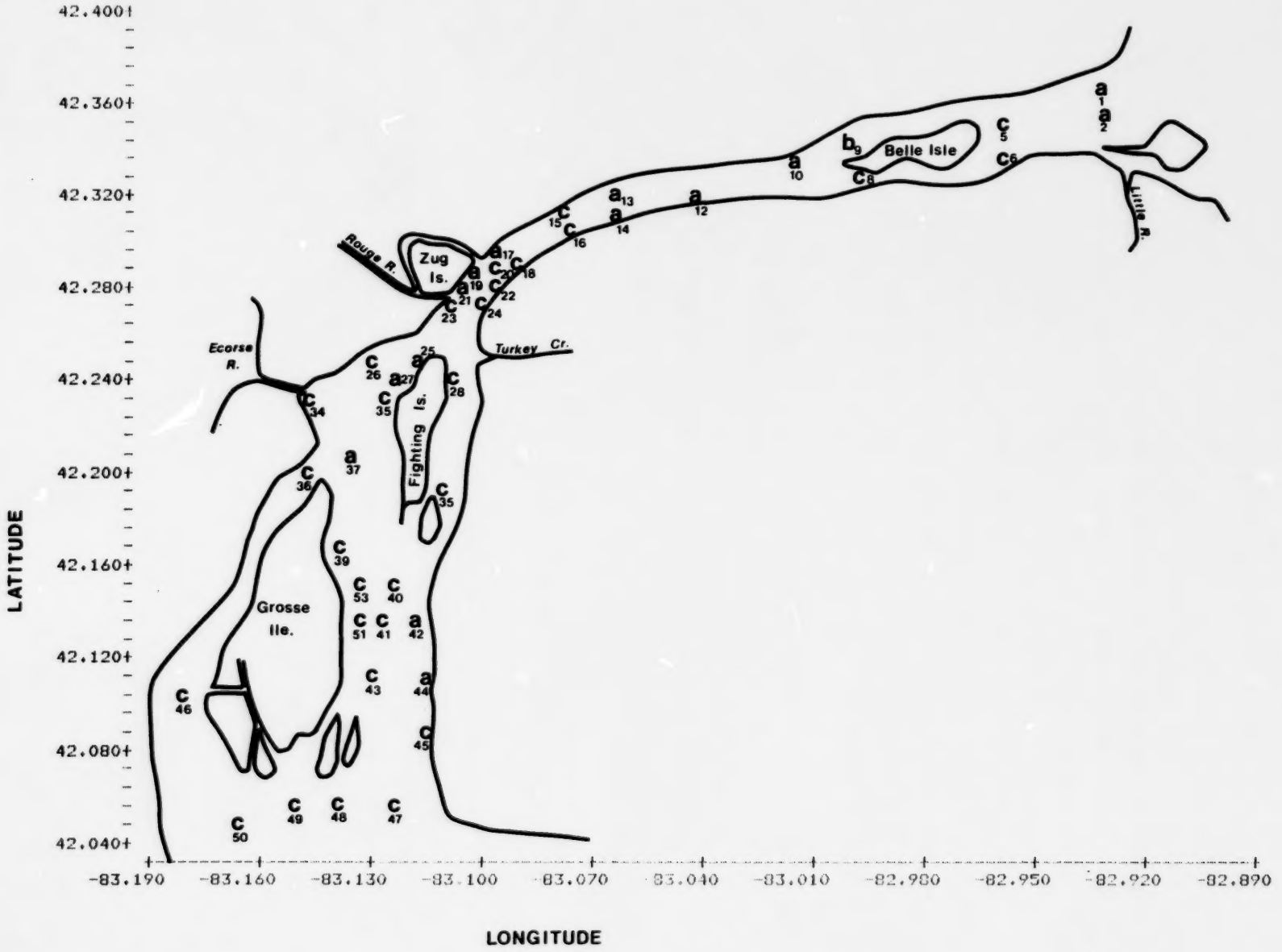

FIGURE 10 DETROIT RIVER THREE-CLUSTER SOLUTION FOR 1980

SEDIMENT QUALITY

Physical Characteristics

Grain size analysis of surficial sediments and distribution of mean grain size (expressed in phi units) along both the Canadian and U.S. shorelines are shown in Table 3 and Figure 11, respectively. In general, sediments of the river are composed of coarse material, mainly sand which constituted about 60% of the sediment composition. There is a slight decrease in mean grain size (ie. increase in phi) at areas with low river current velocities e.g. embayments and the river mouth. In the faster flowing waters such as along the Detroit waterfront and at the entrance of the Trenton Channel along the U.S. shore and in the upper reaches of the Amherstburg Channel along the Canadian shore, gravel dominated the sediment composition.

Based on Folk and Ward's model (6), zones of low energy or depositional areas, are mainly found downstream from Zug Island and the Rouge River mouth, in the Trenton Channel in the vicinity of Trenton, Michigan and along the river mouth (western Lake Erie). Most of the River sediments are characteristic of a high energy environment.

Sediment Chemistry

This section describes the distribution of organic and inorganic trace contaminants and nutrients in the sediments of the Detroit River and delineates zones of sediment impairment. In assessing the significance of contaminants in sediments, reference was made, where applicable, to the Ontario Ministry of the Environment (MOE) guidelines for dredging and open water disposal (7).

Table 3. Grain Size Distribution in Detroit River Sediments, 1980

STN	CAN/USA	DIST DOWN STRM FROM REF. PT.	DISTANCE FROM SHORE M	+---------- SEDIMENTS - PARTICLE SIZE - PERCENT ----------+ GRAVEL 10	VC SAND 18	C SAND 35	MED SAND 60	FINE SAND 120	V.F. SAND 230	SILT	CLAY 2 HRS HMETRE	FINE 3 HRS 12 MIN
D1	A	0.30	100	0.00	0.73	8.41	53.24	32.94	1.99	2.69	0.00	0.00
D2	A	0.05	600	14.66	7.07	8.59	23.57	24.86	2.33	5.52	4.20	4.20
D6	C	2.71	200	67.25	4.25	3.51	6.23	5.61	7.17	5.98	0.00	0.00
D5	A	2.68	150	0.41	0.70	1.51	36.08	54.48	4.11	2.71	0.00	0.00
DA	C	-0.83	600	13.44	5.96	10.99	21.35	40.21	2.81	0.00	2.62	2.62
DB	C	0.28	0	7.31	6.72	8.03	14.11	17.02	11.81	24.77	0.93	9.30
DC	C	0.33	0	27.33	4.33	3.58	14.67	15.40	5.34	18.21	1.01	10.13
DD	C	1.30	475	0.00	0.46	0.57	6.40	41.35	21.47	21.77	7.98	0.00
D8	C	5.97	0	9.76	4.14	4.72	10.50	26.25	12.97	20.49	11.17	0.00
DE	A	7.57	500	0.00	0.81	1.05	5.66	23.02	25.21	42.02	2.23	0.00
D10	A	7.78	150	46.75	5.06	8.76	12.66	21.17	2.83	2.77	0.00	0.00
D9	A	6.47	0	25.98	5.16	5.60	26.78	25.10	7.02	4.36	0.00	0.00
D12	C	9.78	100	24.80	4.83	7.77	32.22	23.66	2.70	4.02	0.00	0.00
DF	A	10.65	125	78.21	6.12	2.35	6.14	4.63	0.54	2.01	0.00	0.00
D13	A	12.27	0	45.18	3.72	2.76	9.07	19.39	9.62	10.26	0.00	0.00
D14	C	11.46	100	52.08	1.96	1.89	5.53	15.55	5.93	12.24	4.82	0.00
D16	C	13.96	100	28.47	0.33	0.59	2.35	19.52	25.71	14.92	8.11	0.00
D15	A	14.17	0	80.00	3.10	2.60	4.10	4.30	1.10	2.00	0.00	2.80
D17	A	16.61	0	0.00	2.39	2.72	6.41	11.71	20.39	49.11	7.19	0.00
D18	C	15.06	100	0.00	0.53	0.92	4.63	62.91	18.52	9.99	2.50	0.00
D20	C	15.78	0	7.72	2.95	1.26	3.86	12.08	3.21	49.24	2.46	17.26
D19	A	17.81	0	15.21	7.38	13.71	21.90	10.82	2.17	15.72	0.00	13.09
D22	C	16.50	0	16.78	3.62	4.58	13.23	32.68	11.18	11.48	3.97	2.48
D21	A	18.58	0	43.74	10.42	11.37	20.93	8.71	1.23	3.60	0.00	0.00
D23	A	19.13	0	3.69	0.75	0.83	3.51	7.61	8.80	64.07	2.24	8.50
D24	C	17.27	0	6.59	2.19	2.57	5.56	9.84	5.35	34.17	1.16	32.12
DG	C	19.93	475	1.65	0.87	2.75	26.21	44.60	7.43	12.59	0.00	3.90
D25	C	20.21	700	4.93	5.51	3.18	5.26	4.25	0.63	45.08	1.95	29.26
D26	A	22.44	0	4.80	3.30	5.29	11.77	18.72	25.34	30.78	0.00	0.00
D27	C	20.56	1150	61.54	4.49	1.91	2.47	19.04	3.32	3.71	0.00	3.52
DJ	C	21.69	340	9.51	1.48	1.56	5.37	31.39	16.25	27.28	2.64	4.52
D28	C	21.86	100	6.50	0.89	0.70	1.80	48.00	28.00	12.11	0.00	2.00
D34	A	24.62	100	0.20	0.11	0.21	0.90	11.00	49.00	30.88	0.00	7.70
DI	A	27.71	375	74.00	4.50	2.80	4.40	5.70	2.50	2.67	0.85	2.60
D36	A	27.89	0	51.00	7.80	4.60	4.10	13.00	7.60	8.60	0.00	3.30
D37	A	27.50	950	15.00	3.80	4.60	6.30	10.00	7.40	22.60	3.30	27.00
DH	C	24.84	2180	1.50	5.10	4.20	7.30	11.00	6.40	39.10	6.40	19.00
D35	C	22.41	1875	0.00	0.12	0.19	0.44	1.10	11.00	51.25	5.90	30.00
DK	A	24.80	1200	6.80	1.10	2.90	15.00	49.00	13.00	4.70	1.90	5.60
DL	C	25.09	390	25.00	0.67	0.70	2.20	6.00	14.00	35.63	4.80	11.00
D33	C	26.04	625	12.00	2.30	2.60	4.30	5.70	4.60	29.70	4.80	34.00
DN	C	30.09	975	1.30	0.66	0.81	2.40	5.80	24.00	41.03	2.00	22.00

STN	CAN/USA	DIST DOWN STRM FROM REF. PT.	DISTFROM	SHORE	+---------- SEDIMENTS - PARTICLE SIZE - PERCENT ---------- GRAVEL 10	VC SAND 18	C SAND 35	MED SAND 60	FINE SAND 120	V.F. SAND 230	SILT	CLAY 2 HRS HMETRE	F I 3 HRS 12 MIN
DM	C	29.14	1400		0.09	0.34	0.23	1.20	15.00	39.00	28.14	2.00	14.00
D39	A	32.00	2150		27.00	0.42	0.40	2.70	27.00	18.00	13.48	0.00	11.00
D53	A	33.85	3250		60.00	6.60	4.30	4.30	3.50	4.30	8.60	0.00	8.40
D40	C	30.91	950		0.47	0.16	0.33	2.20	40.00	32.00	14.54	1.50	8.88
D51	A	35.59	3575		3.60	0.34	5.40	9.40	39.00	18.00	18.26	1.40	8.60
D41	A	35.55	4080		2.60	2.20	4.70	13.00	22.00	29.00	17.50	0.00	9.00
D42	C	32.59	200		4.30	4.20	4.40	15.00	48.00	7.00	7.10	0.00	10.00
D43	A	38.87	4550		0.06	0.09	0.27	1.10	3.90	8.70	59.68	3.20	23.00
D44	C	35.39	100		56.00	7.30	5.40	8.70	6.20	2.20	7.68	0.82	5.70
D47	C	41.89	1000		15.00	11.00	17.00	41.00	10.00	1.40	0.00	4.60	0.00
D48	C	41.89	1925		0.00	0.10	0.22	0.55	2.50	19.00	55.63	2.00	20.00
D49	A	45.07	3030		0.00	0.42	0.42	0.87	1.80	13.00	60.69	3.80	19.00
D50	A	45.14	1925		0.39	0.42	2.00	15.00	32.00	3.60	40.79	0.00	5.80
D46	A	39.77	700		4.30	2.30	4.90	27.00	35.00	14.00	4.80	3.00	7.70
DO	A	34.15	0		0.00	3.00	3.60	2.30	2.20	2.80	62.00	6.10	18.00
DP	A	34.23	425		0.19	0.21	1.00	6.30	61.00	22.00	0.00	3.60	5.70
D45	C	38.06	250		11.00	1.60	1.30	3.00	21.00	32.00	17.50	2.60	10.00

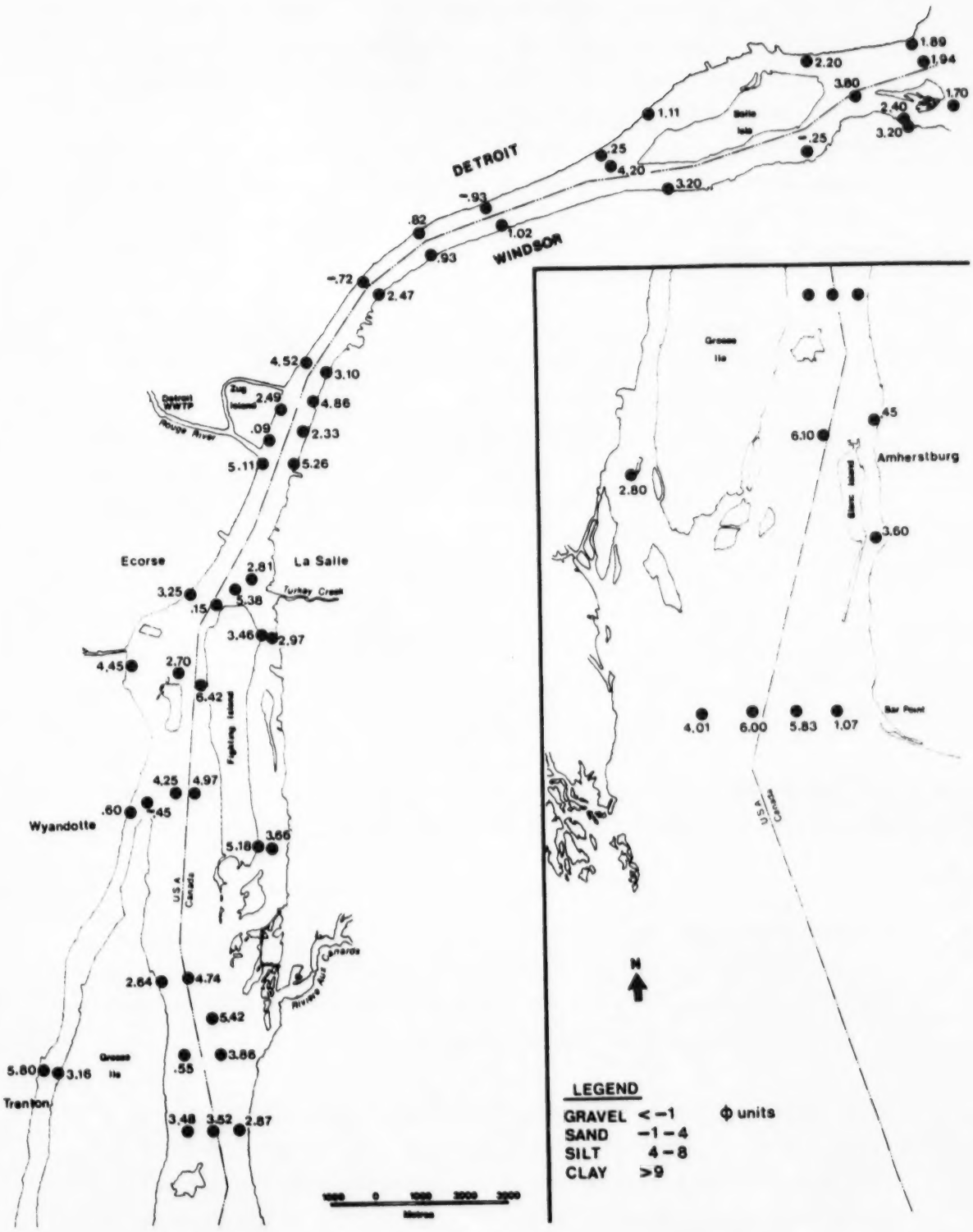

FIGURE 11 DISTRIBUTION OF MEAN GRAIN SIZE (EXPRESSED IN PHI(ϕ) UNITS) IN THE DETROIT RIVER, 1980.

Heavy Metals

The mercury concentration distribution in the Detroit River sediments, shown in Figure 12, indicates that concentrations in excess of the Ontario guideline for open-water disposal of dredged materials for mercury (0.3 mg/kg) were detected in 30% of the stations sampled in the Detroit River. The range of concentrations along the U.S. shore was 0.01-8.10 mg/kg, with a mean of 0.6 mg/kg, whereas the range for the Canadian shore was 0.01-0.6 mg/kg with a mean of 0.2 mg/kg.

The distribution of mercury levels suggested two areas of significant impairment, both are confined to the U.S. shoreline. The area along the eastern shore of Zug Island extending from Fort Wayne to River Rouge exhibited a maximum level of 1.2 mg/kg. This area is characterized by numerous industries, e.g. Great Lakes Steel Division of National Steel Corp. and the municipal sewage treatment plant for the city of Detroit.

In the Trenton Channel, west of Grosse Ile, the highest level of mercury (8.1 mg/kg) in the study area was observed. The mercury losses from the chlor-alkali plant at Wyandotte had contributed to the sediment contamination in this channel.

Mercury levels around Fighting Island (ranging from 0.01 to 0.30 mg/kg) showed compliance with the dredging guideline for open water disposal.

Thomas and Jaquet and Frank et al (8, 9) suggested that sources located along the Detroit River shoreline contribute to the river contamination (e.g. mercury and organics) more significantly than those transported from Lake St. Clair.

Improvements in industrial treatment facilities, such as those occurred in chlor-alkali plants at Wyandotte by replacement of the mercury cell by the diaphragm cell, contributed to significant decreases in mercury levels in 1980 as compared to those found in a previous Ministry study during 1970. The mercury concentration distribution during that year is shown in Figure 13. Levels at or

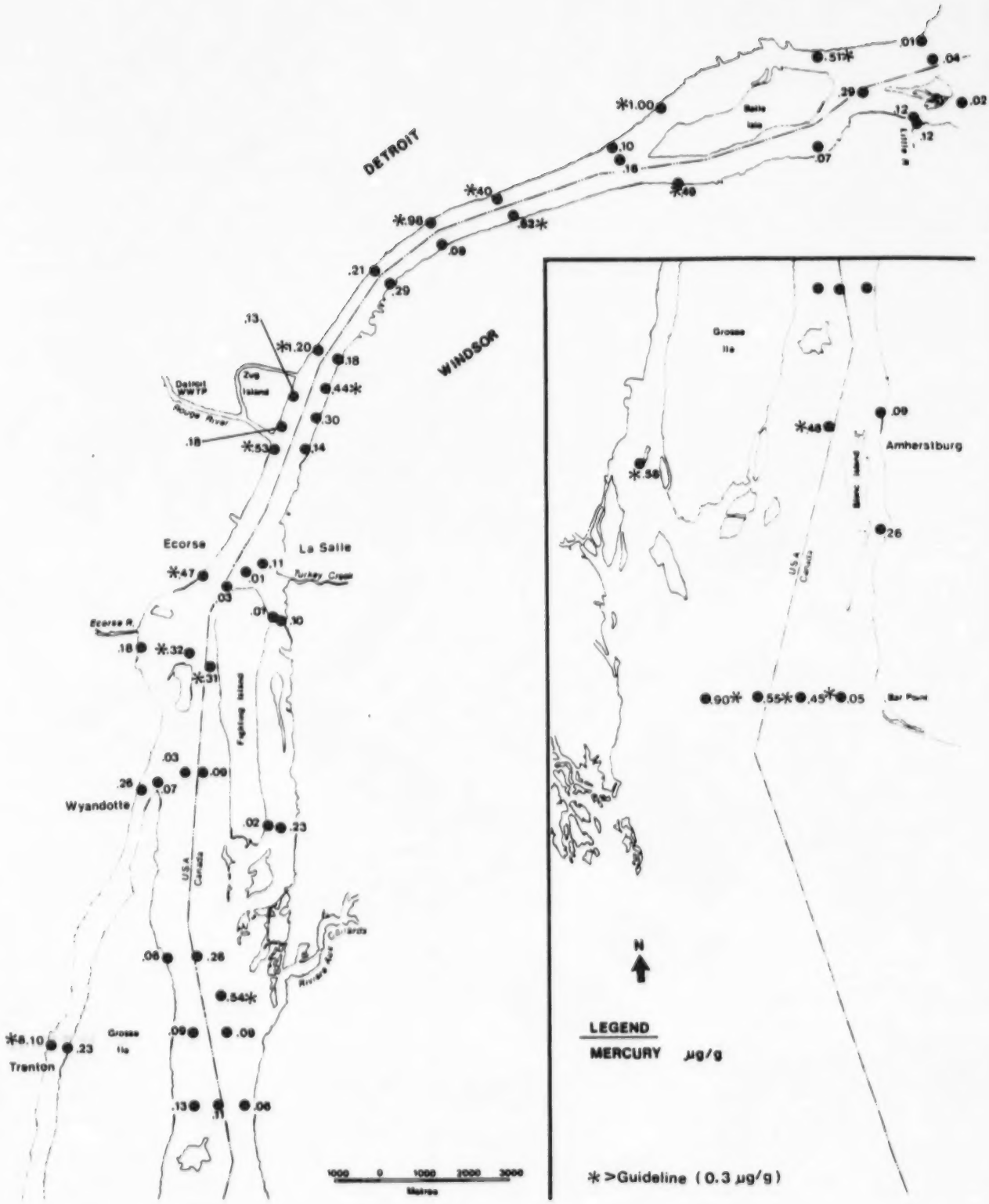

FIGURE 12 DISTRIBUTION OF MERCURY(UG/G) IN DETROIT RIVER SEDIMENTS, 1980.

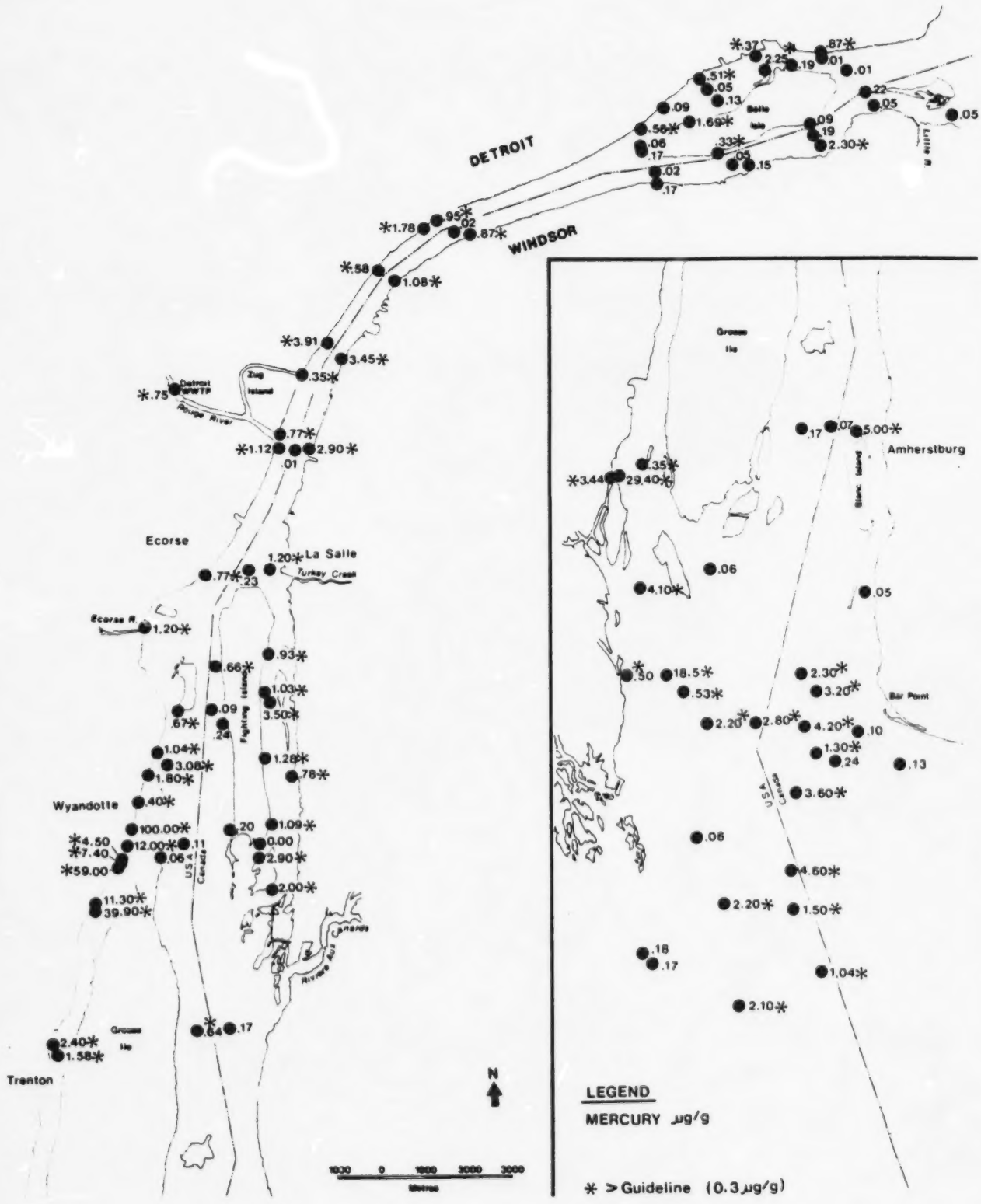

FIGURE 13 DISTRIBUTION OF MERCURY (UG/G) IN DETROIT RIVER SEDIMENTS, 1970

below the Ministry guideline of open water disposal (0.3 mg/kg) were prevalent at 34% of the stations sampled in 1970 whereas 70% of the stations were below the guideline in 1980, as indicated by the percent relative frequency distribution in 1970 and 1980 (Figure 14 and 15). Also, it is worth noting that levels greater than 10 mg/kg that were recorded at 8% of the samples in 1970 were not detected in the present study.

The decline in mercury levels was most evident along the reach from Belle Isle to Zug Island where mean concentrations decreased from 1.2 mg/kg in 1970 to 0.6 mg/kg in 1980. Also, at the river mouth, a ten fold decrease was observed during the same period. Although the sampling of sediments in the Trenton Channel was not as extensive as that in 1970, indications are that mercury levels in the channel have also decreased.

This downward trend in mercury levels is also reflected by the decrease of levels of mercury in sport fish from the Detroit River (Table 4).

Other heavy metals such as cadmium, chromium, copper, total iron, lead, nickel and zinc showed levels in excess of the dredging guideline for open water disposal in areas downstream from the Little River (sewage treatment plant) and adjacent to the Windsor waterfront (urban runoff input) along the Canadian shore (Figures 16-18). At these locations all of the above metals exceeded the Ontario guidelines for open-water disposal.

Almost the entire American shoreline indicated heavy metal levels above the guidelines (Figures 16-18). Levels of chromium, copper, lead, nickel and zinc at the Rouge River mouth in 1980 were considerably greater than those found in 1970 (12) (Table 5) which indicate the existance of recent inputs of heavy metals into the Detroit River from industry and the Detroit sewage treatment plant.

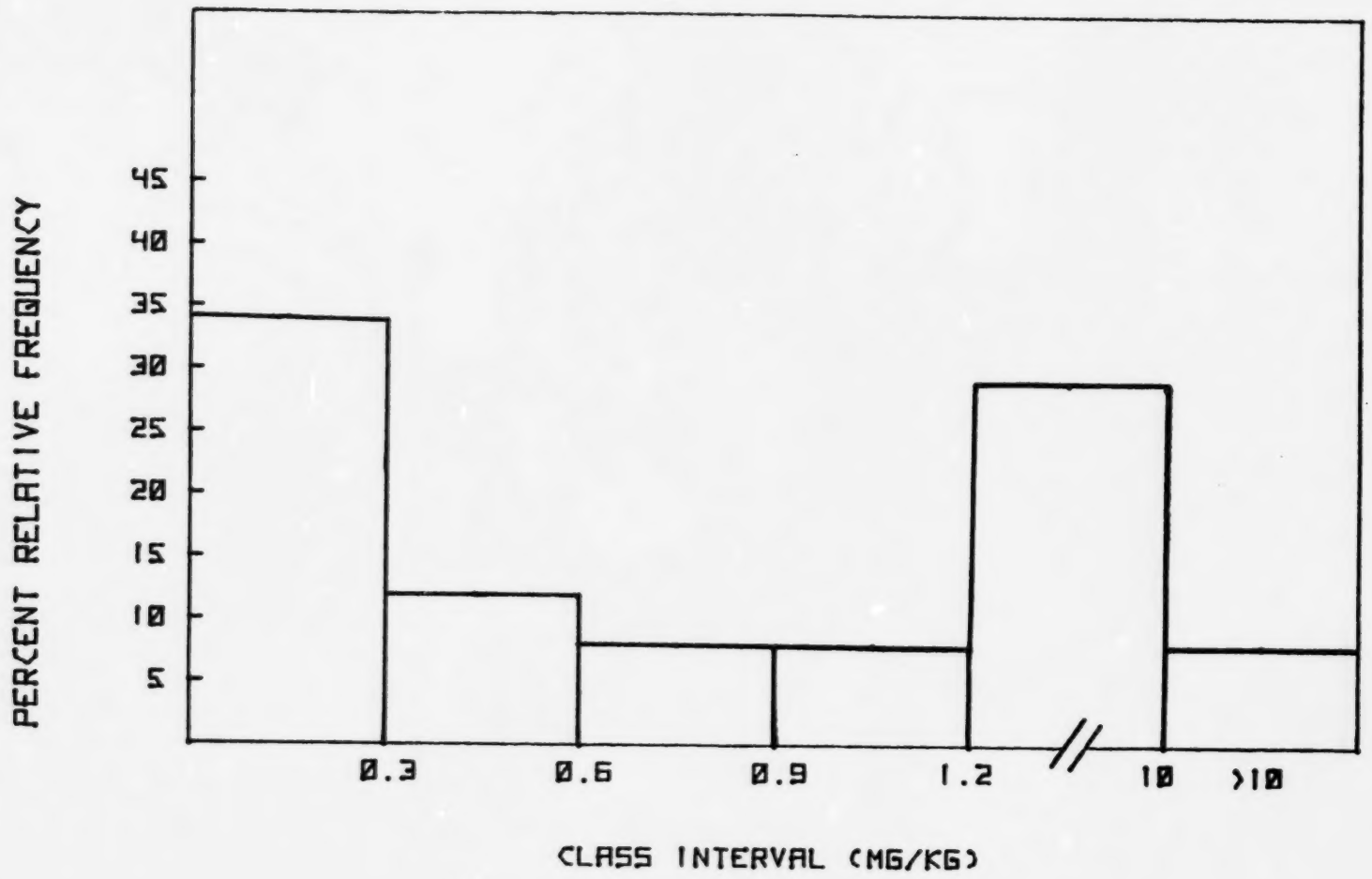

FIGURE 14 HISTOGRAM OF DETROIT RIVER MERCURY DISTRIBUTION FOR 1970

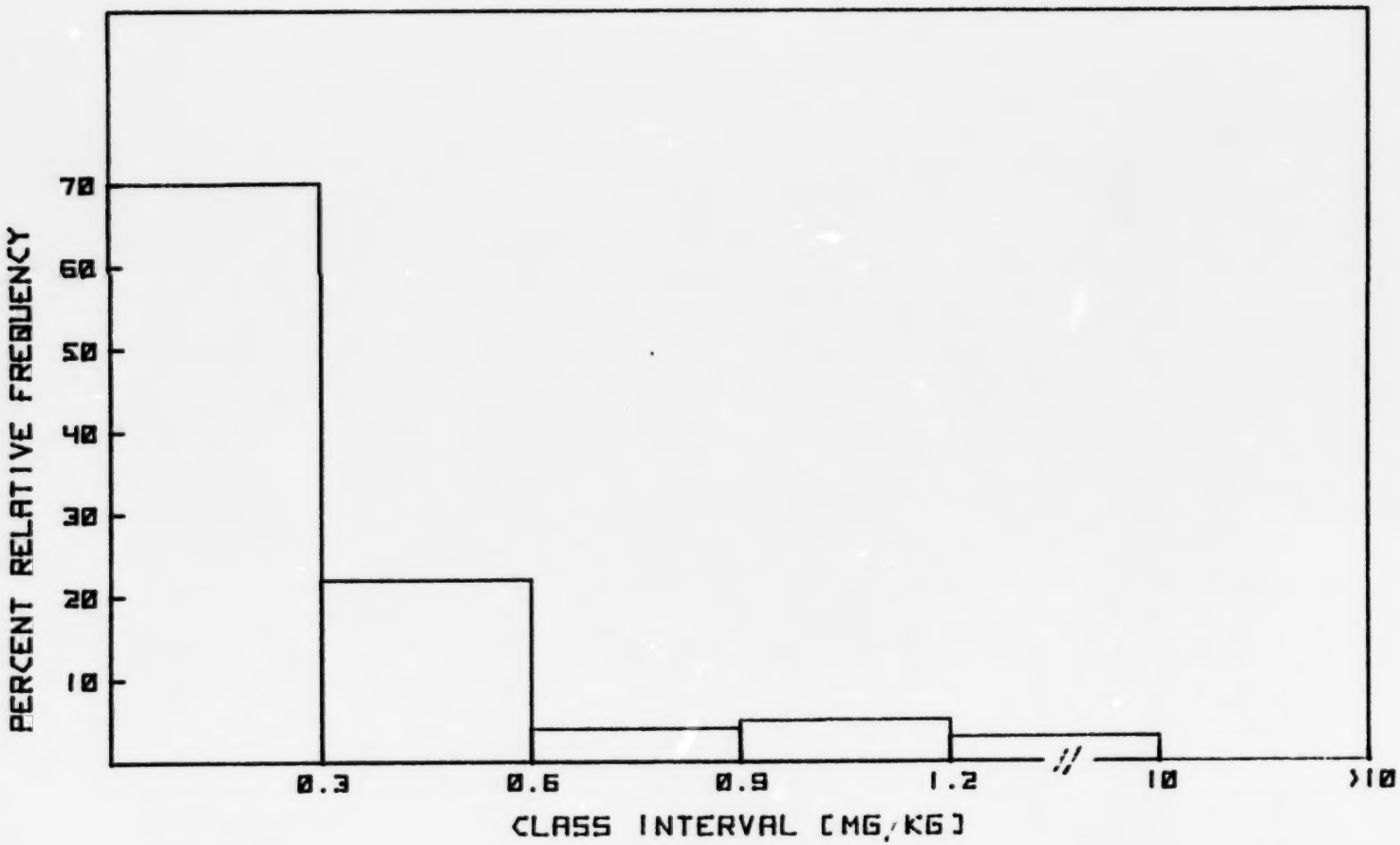

FIGURE 15 HISTOGRAM OF DETROIT RIVER MERCURY DISTRIBUTION FOR 1980.

Table 4. Concentrations of Mercury in Various Species of Detroit River Sport Fish, 1968-1981.

Year	Species	Number of Species	Mercury (ppm) Mean	Range
1968	Carp	6	0.82	0.10-1.70
1968	Northern Pike	8	0.80	0.61-0.99
1970	Northern Pike	4	0.17	0.12-0.28
1971	Northern Pike	12	0.59	0.12-0.99
1971	Carp	6	0.65	0.10-1.40
1978	Walleye	20	0.31	0.16-0.77
1978	W. Bass	21	0.30	0.12-0.86
1978	R. Bass	7	0.50	0.29-0.79
1980	Y. Perch	18	0.14	0.06-0.38
1981	Walleye	20	0.20	0.10-0.39
1981	R. Bass	20	0.31	0.06-0.97
1981	W. Bass	20	0.25	0.07-0.84
1981	F.W. Drum	20	0.35	0.07-0.58

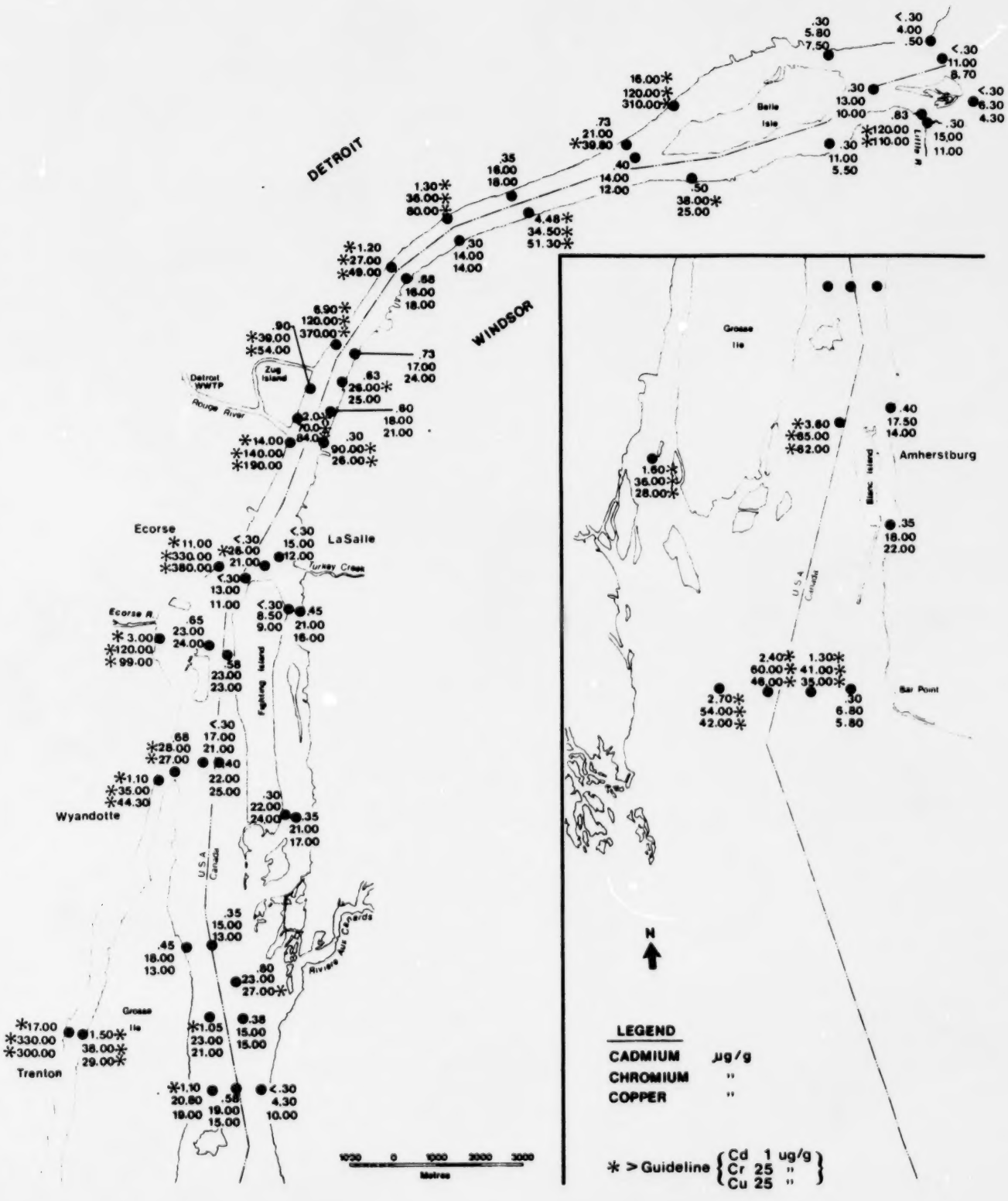

FIGURE 16 DISTRIBUTION OF CADMIUM, CHROMIUM AND COPPER(UG/G), IN DETROIT RIVER SEDIMENTS, 1980.

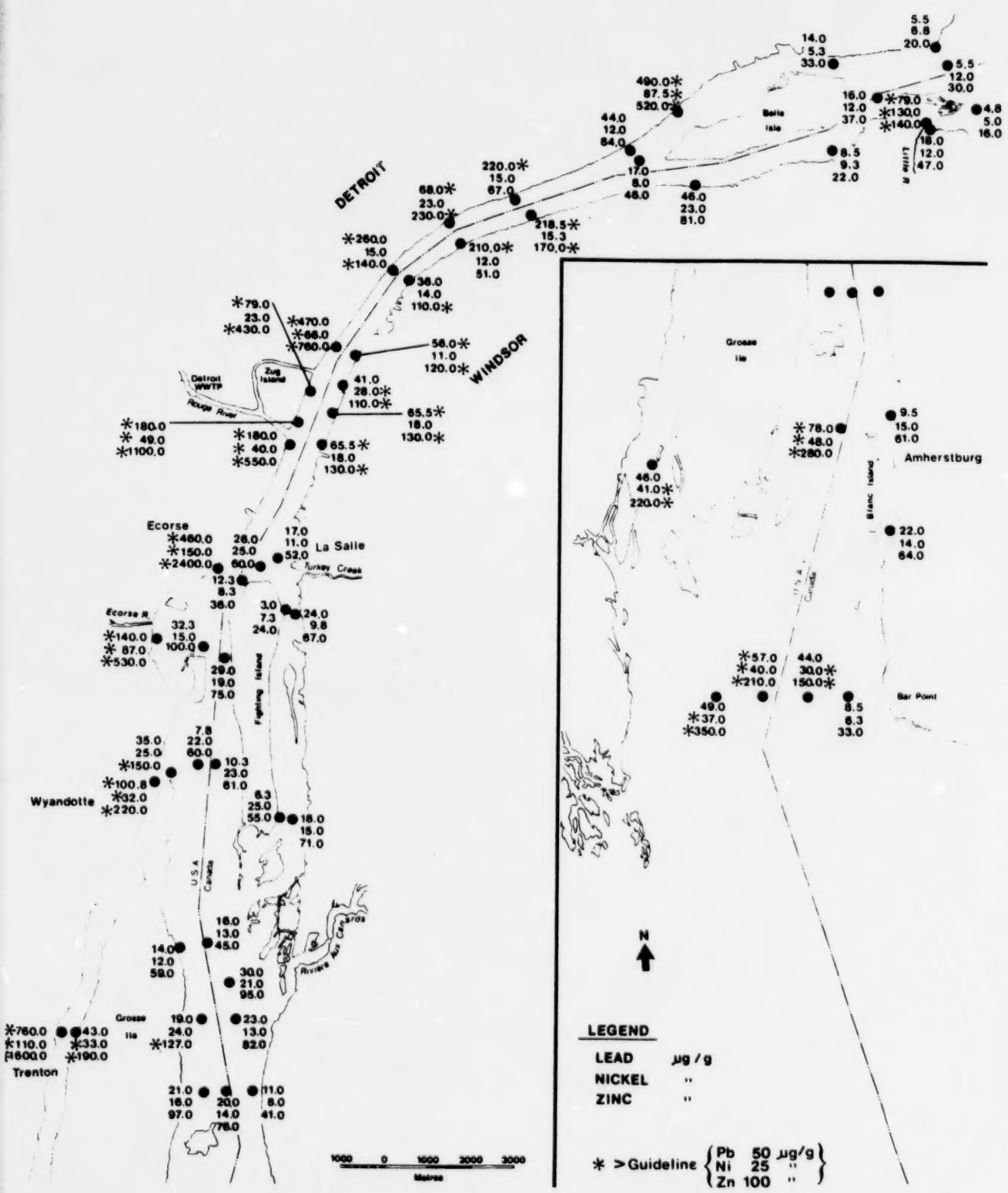

FIGURE 17 DISTRIBUTION OF LEAD, NICKEL AND ZINC(UG/G), IN DETROIT RIVER SEDIMENTS, 1980.

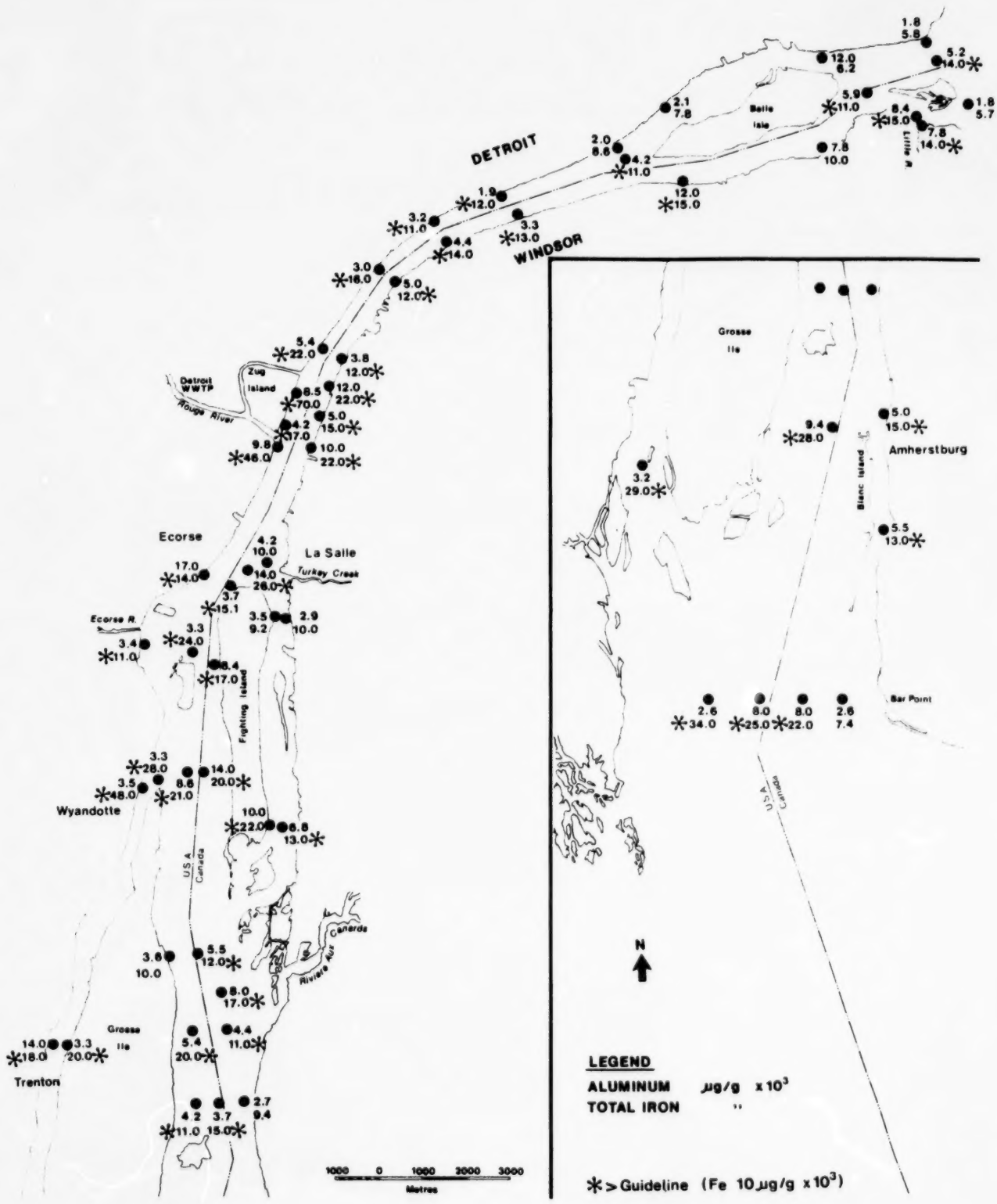

FIGURE 18 DISTRIBUTION OF ALUMINUM AND TOTAL IRON(UG/G X 10^3) IN DETROIT RIVER SEDIMENTS, 1980.

Table 5. Comparison of 1970 and 1980 Heavy Metal Concentrations for the Mouth of the Rouge River.

Sample Date	Concentration in mg/kg dry weight					
	Cadmium	Chromium	Copper	Lead	Nickel	Zinc
1970	<30.0	26.0	41.0	54.0	30.0	110.0
1980	14.0	140.0	190.0	180.0	40.0	550.0

Table 6. Comparison of 1970 and 1980 Heavy Metal Concentrations for the Mouth of the Ecorse River.

Sample Date	Concentration in mg/kg dry weight					
	Cadmium	Chromium	Copper	Lead	Nickel	Zinc
1970	<30.0	540.0	290.0	900.0	230.0	1,300.0
1980	3.0	120.0	99.0	140.0	87.0	530.0

Sediments analyzed from a station located immediately downstream from the mouth of the Ecorse River, at the American shoreline, showed levels above the dredging guidelines for all seven parameters. However, these levels were considerably less than those reported at the mouth of the Ecorse River in 1970 (12) as shown in Table 6.

Levels of heavy metals along the east and west shores of Fighting Island were well below the provincial guidelines.

In the Trenton Channel sediments in the vicinity of Trenton, Michigan, dredging guideline exceedances were also observed for all seven heavy metals. This station, which is located in a depositional zone, was also found to have the maximum concentrations observed throughout the whole river for three of these parameters; cadmium (17.0 mg/kg), chromium (330.0 mg/kg) and lead (760.0 mg/kg).

Except for the station closest to the Canadian shore, sediments at the Detroit River mouth showed levels exceeding the dredging guidelines for all of the heavy metals analyzed. When compared with Detroit River mouth sampling results from 1970, however, levels for cadmium, chromium, copper, lead, nickel and zinc in 1980 are considerably less. This declining trend was also found in the Western Basin of Lake Erie as documented by the Ministry's study in 1979 (13).

In general, heavy metals correlated poorly ($P > 0.1$) with sediment texture suggesting that sources in the river are the major contributors. In addition, metal concentrations were, in general, highly intercorrelated ($P < 0.005$) along the U.S. shore, indicating that continuous rather than discrete sources were responsible. Along the Canadian shore, however, metal levels were attributed to localized sources since intercorrelation between metal concentrations was generally poor ($P > 0.1$).

PCBs and Solvent Extractables

Concentrations of PCBs in excess of the Ontario guideline for open water disposal of dredged materials (50 ug/kg) were detected in 59% of the stations sampled in the Detroit River. The range of concentrations was from less than 1 ug/kg to 3800 ug/kg for the American stations and from less than 1 ug/kg to 370 ug/kg for the Canadian stations (Figure 19).

The sediments upstream of Belle Isle were relatively free of PCB contamination. The area immediately downstream from the mouth of the Little River STP had an elevated level of PCBs (370 ug/kg). Along the Windsor waterfront and as far as Turkey Creek, levels in excess of the dredging guideline were prevalent and ranged from 70 to 260 ug/kg. This contamination with PCBs is likely attributed to inputs from storm and combined overflow sewers, the Windsor sewage treatment plant and inputs from Turkey Creek.

PCBs were not detected in sediments taken from the river around the shoreline of Fighting Island.

A higher degree of contamination was observed along the U.S. shore and persisted for almost the entire shoreline. The highest levels observed in sediments from the U.S. portion of the river were in the vicinity of Fort Wayne (2960 ug/kg), Zug Island (2840 ug/kg), Ecorse, Michigan (3800 ug/kg), and in the Trenton Channel opposite Trenton, Michigan (1580 ug/kg).

Frank et al (9) showed that the large flux of PCBs from the Detroit River to western Lake Erie is associated with the west bank water masses and attributed to the urban industrial complex of metropolitan Detroit.

The solvent extractables (oil and grease) distribution exhibited a pattern similar to that of PCBs with most violations of the MOE dredging guideline (1500 mg/kg) occurring along the U.S. shoreline.

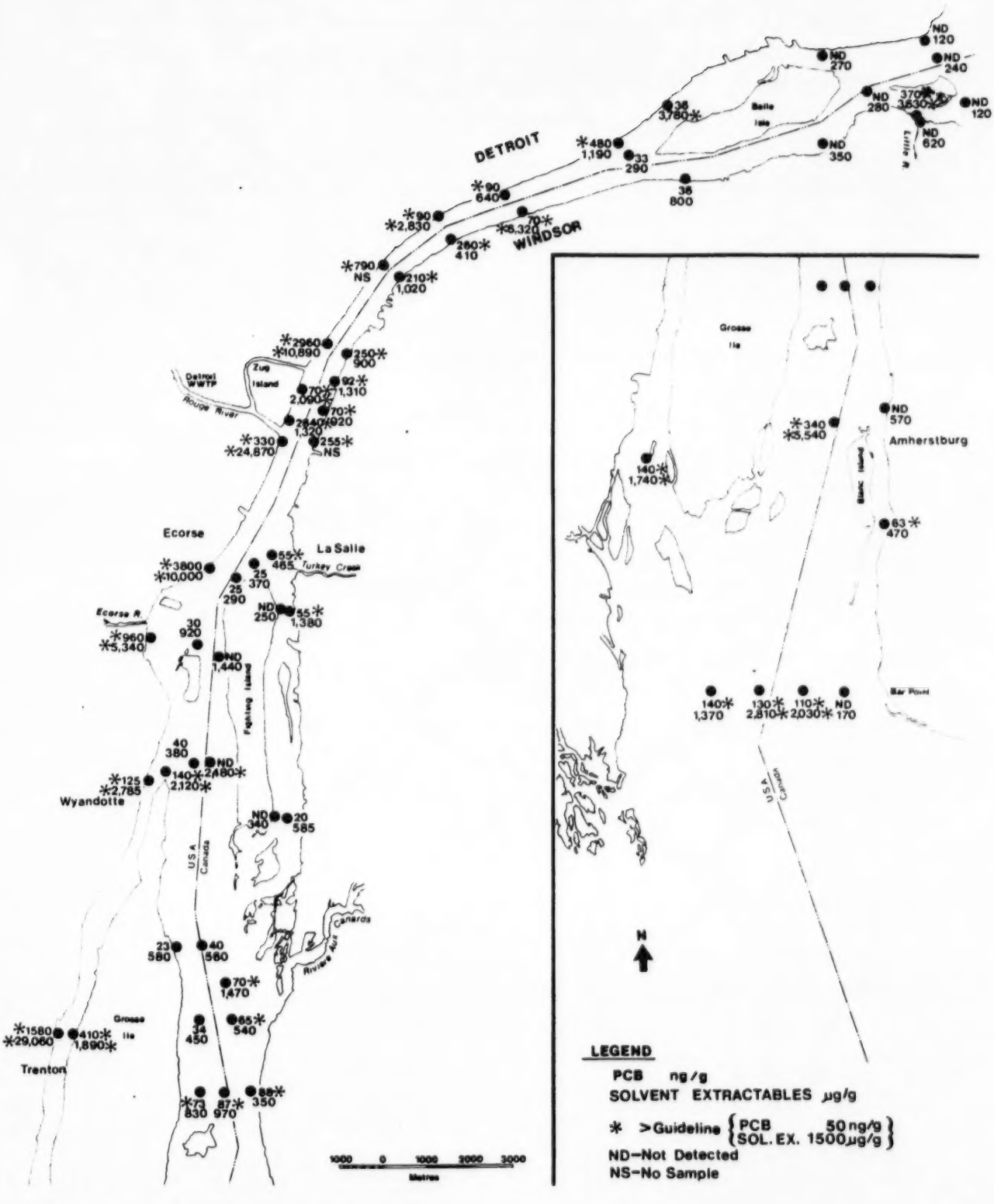

FIGURE 19 DISTRIBUTION OF PCBS(NG/G) AND SOLVENT EXTRACTABLES(UG/G) IN DETROIT RIVER SEDIMENTS, 1980

Organochlorine Pesticides

The sum of DDT and its metabolites was not detected in sediments along the Canadian shore with the exception of areas in the vicinity of storm and combined overflow sewers for the City of Windsor and downstream from Riviere Aux Canards (Figure 20). Similarly, hexachlorobenzene (Figure 21), the three isomers of benzenehexachloride (α, β, and γ), the sum of the alpha and beta isomers of endosulphan and the sum of alpha and gamma isomers of chlordane (Figure 20) were not detected at the majority of stations along the Canadian shore.

Organochlorine pesticides were not detected in sediments around Fighting Island.

Along the U.S. shoreline of the river, the highest levels of pesticides were observed in the vicinity of Fort Wayne, Michigan, Zug Island and Rouge River and Trenton, Michigan. Levels of the sum of DDT and its metabolites were 16,000 ug/kg at Fort Wayne, 140 ug/kg at Zug Island and 186 ug/kg at Trenton, Michigan. Sediments from the Trenton Channel also contained a level of 360 ug/kg for HCB, the highest observed in the river.

With the exception of the sum of DDT, sources of heptachlor epoxide and chlordane are mainly attributed to discharges from both the U.S. and Canadian shorelines, since these compounds were absent from Lake St. Clair sediments as found by Frank et al (9).

Nutrients

The concentration distribution of percent loss on ignition, total phosphorus and total Kjeldahl nitrogen is shown in Figure 22. Fourteen percent of the sediment samples had values for percent loss on ignition (ie. organic content) above the provincial guideline (6%). The range for this parameter was 0.68%-21.00%, with an average of 3.47% in the Canadian portion of the river and 0.60%-16.00%, with an average of 3.68% for the U.S. portion of the

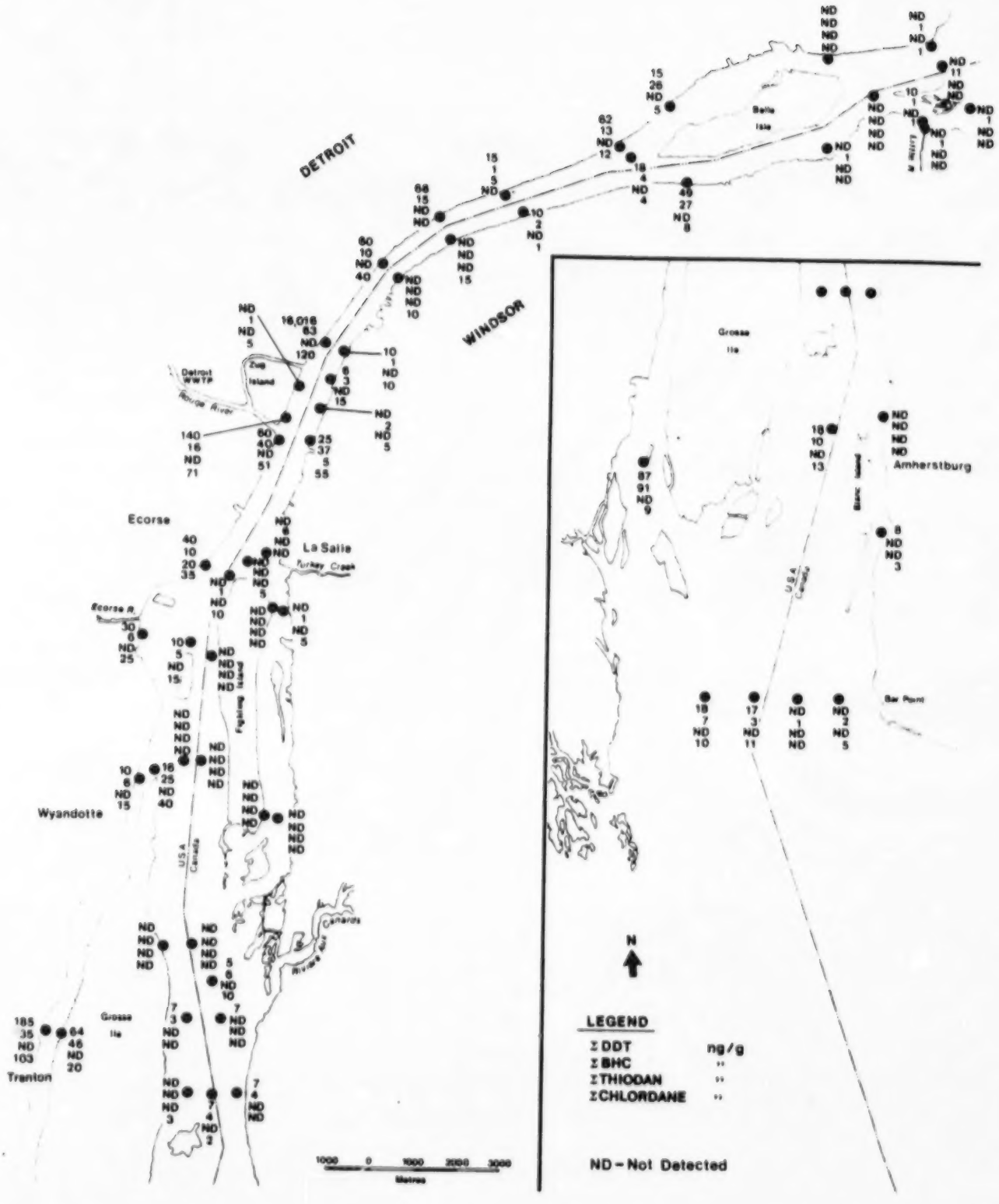

FIGURE 20 DISTRIBUTION OF ΣDDT, BHC, THIODAN AND CHLORDANE(NG/G), IN DETROIT RIVER SEDIMENTS, 1980.

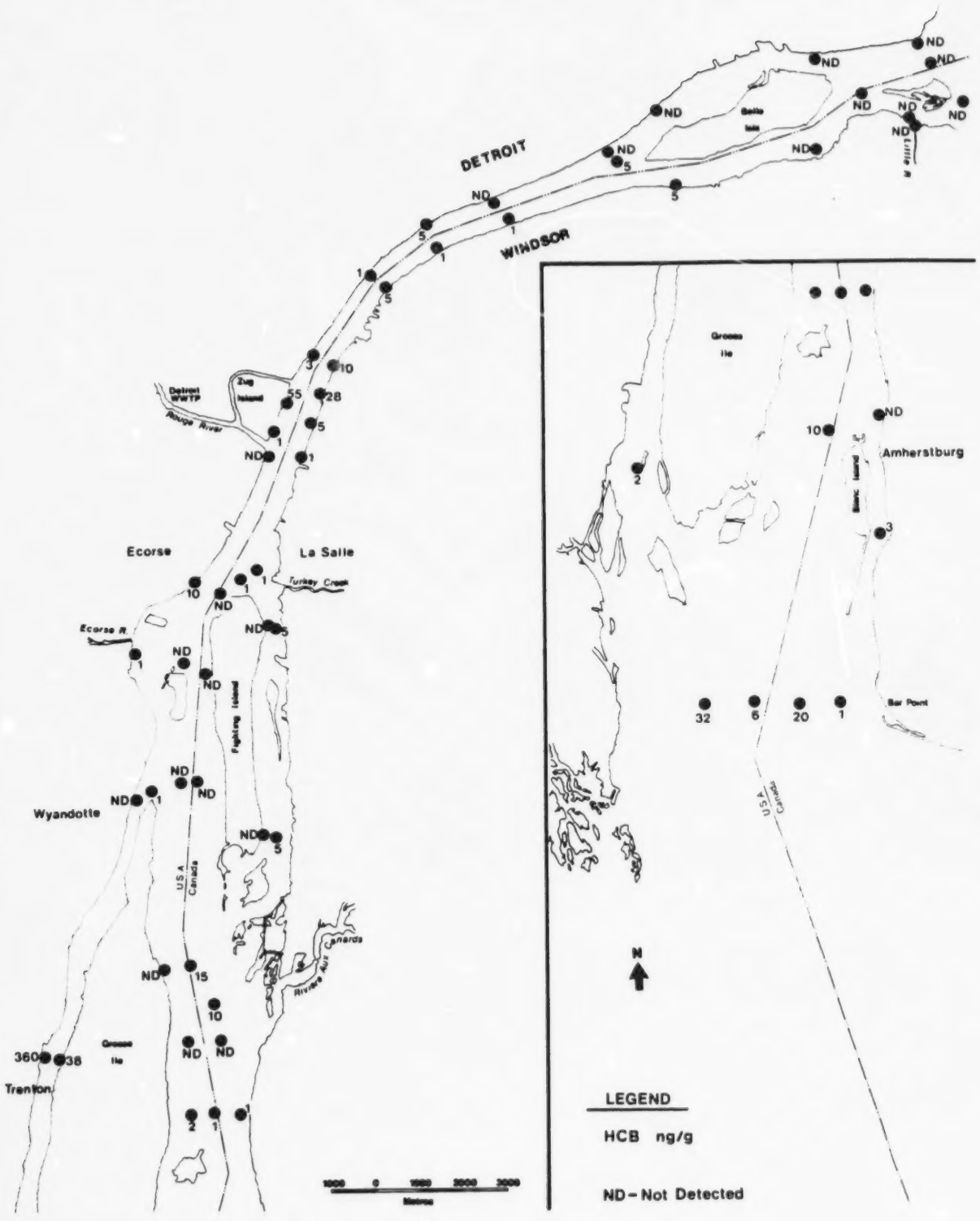

FIGURE 21 DISTRIBUTION OF HEXACHLOROBENZENE (NG/G) IN DETROIT RIVER SEDIMENTS, 1980.

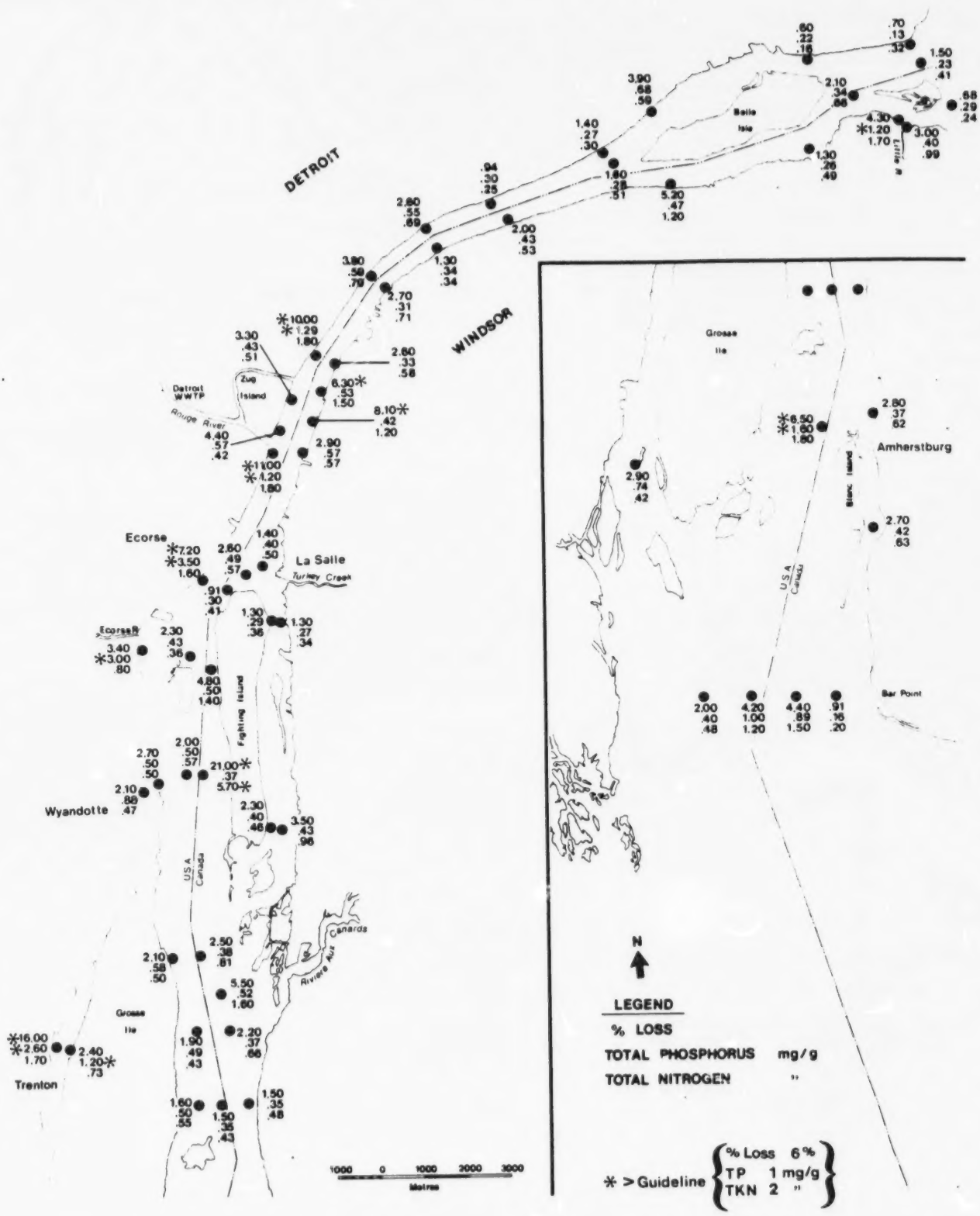

FIGURE 22 DISTRIBUTION OF % LOSS ON IGNITION, TOTAL PHOSPHORUS AND TOTAL KJELDAHL NITROGEN(MG/G), IN DETROIT RIVER SEDIMENTS, 1980.

river. The highest values for percent loss on ignition were found in sediment samples from Fort Wayne, Michigan (10%), immediately downstream from the mouth of the Rouge River (11%) and in the Trenton Channel (16%) along the American shore; and just east of the international boundary, west of Fighting Island, opposite Wyandotte, Michigan (21%).

Concentrations in excess of the Ontario guideline for open-water disposal of dredged materials for total phosphorus (1000 mg/kg) were detected in 15% of the stations sampled in the Detroit River. The range of concentrations was 130-3500 mg/kg, with a mean of 862 mg/kg for the American stations and 160-1200 mg/kg, with a mean of 427 mg/kg for the Canadian stations.

The majority of the areas (89%) having phosphorus level violations were found in the U.S. portion of the river. No large zones of impairment were observed, only isolated stations with high phosphorus levels. The distribution of phosphorus in the sediments did suggest some relationship to direct and indirect point sources entering the river. Downstream from the Little River, a localized area of contamination (1200 mg/kg) was observed, reflecting the effect of the Little River STP discharge); immediately below the Rouge River (which receives the Detroit STP outfall) (1200 mg/kg), near Ecorse, Michigan (3500 mg/kg), below the mouth of the Ecorse River (3000 mg/kg) and by Trenton, Michigan (2600 mg/kg).

Total Kjeldahl nitrogen distribution in the sediments was quite similar to that of phosphorus. Levels were generally approaching the dredging guideline of 2000 mg/kg. The highest level was found just east of the international boundary, west of Fighting Island, opposite Wyandotte, Michigan (5700 mg/kg). This, as well as the high loss on ignition value found at this station, reflect the depositional nature of the area and heavy macrophyte growth.

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